

# U.S. ARMY SUBMISSION OF PROPOSALS

## *Topics*

The Army participates in one solicitation each year with a two-tiered Phase I and Phase II proposal evaluation and selection process. The Army has identified 167 technical topics and the Phase III dual-use applications for each which address Army mission requirements. Each topic relates to one of the following 10 technology areas described in the Defense Technology Area Plan (DTAP):

1. Air Platforms
2. Chemical/Biological Defense and Nuclear
3. Information Systems Technology
4. Ground and Sea Vehicles
5. Materials/Processes
6. Biomedical
7. Sensors, Electronics and Battlespace Environment
8. Space Platforms
9. Human Systems
10. Weapons

A definition of these technology areas and a discussion of the DTAP are located on the Internet at [http://www.dtic.mil/dstp/97\\_docs/dtap/dtaps.htm](http://www.dtic.mil/dstp/97_docs/dtap/dtaps.htm). Please do not submit SBIR proposals against the above general technology areas. Only proposals submitted against the specific topics following this introduction will be accepted.

## *New This Year*

- T The Army now requires proposers to submit their Proposal Cover Sheet (Appendix A) and Project Summary (Appendix B) electronically through the Army SBIR Website (address: <http://www.aro.army.mil/arowash/rt/> ). Prior to accessing the Appendix A&B templates, you must register your company on this Website. You must print out these forms directly from the Website, sign them, and submit them with the hard copies of your proposal. Please note that a proposal is not considered accepted until the Army receives the entire packet in hard copy. Please read the detailed instructions which follow.
- T The DoD now requires that all proposers submit their Commercialization Report (Appendix E) electronically to a centralized DoD SBIR Website. As with the Appendix A and B, you must print out this form from the Website, sign it, and submit it with the hard copies of your proposal. Refer to section 3.4n at the front of this solicitation for detailed instructions. Please note that improper handling of this form may result in the proposal being substantially delayed. Information provided may have a direct impact on the review of the proposal.
- ✓ The Army only accepts proposals with a base Phase I effort not to exceed \$70,000 and an option not to exceed \$50,000 to conduct initial Phase II activities, should the project be accepted for transition to Phase II.
- ✓ **Phase II Plus** is a three-year pilot program to be implemented immediately as of release of the 99.2 DoD SBIR solicitation. The objectives of **Phase II Plus** are to (1) extend Phase II R&D efforts beyond the current Phase II contract to meet the product, process, or service requirements of a third party investor, preferably an acquisition program, and (2) accelerate the Phase II project into the Phase III commercialization stage. "Third party investor" means Army (or other DoD) acquisition programs as well as the private sector. The general concept is to provide qualified Phase II businesses with additional Phase II SBIR funding if they can obtain matching non-SBIR funds from acquisition programs, the private sector, or both. Under **Phase II Plus**, additional funds may be provided by modifying the Phase II contract, and where appropriate, use will be made of the flexibility afforded by the SBA 1993 Policy which allows total Phase I + Phase II SBIR funding to exceed \$850,000. Additional SBIR matching funds, subject to availability, will be provided on a one-to-one matching basis with third-party funds, but not to exceed to \$100,000. The additional SBIR funds must be used for advancing the R&D-related elements of the project; third-party investor funds can be used for R&D or other business-related efforts to accelerate the innovation to commercialization. More information will be available on the Army SBIR Website address: <http://www.aro.army.mil/arowash/rt/>.

### ***Operation and Support Cost Reduction (OSCR)***

The U. S. Army spends a large part of its overall budget, directly or indirectly, on the operation and support (O&S) of equipment ranging from small generators to large, sophisticated weapon systems. O&S costs cover a broad spectrum of items including spare/repair parts, fuels, lubricants, and the facilities and people involved in training operators and mechanics. The Army is seeking ways to reduce these costs as a broad Acquisition Reform initiative. To this end, the Army has implemented the Operation and Support Cost Reduction (OSCR) Program. This solicitation includes 62 topics that address specific OSCR concerns identified by the Army's research and development community.

### ***Phase I Proposal Guidelines***

The Army has enhanced its Phase I-Phase II transition process by implementing the use of a Phase I Option that the Army may exercise to fund interim Phase I - II activities while a Phase II contract is being negotiated. The maximum dollar amount for a Phase I is \$70,000. The Phase I Option, which must be proposed as part of the Phase I proposal, covers activities over a period of up to four months and at a cost not to exceed \$50,000. All proposed Phase I Options must be fully costed and should describe appropriate initial Phase II activities which would lead, in the event of a Phase II award, to the successful demonstration of a product or technology. **The Army will not accept Phase I proposals which exceed \$70,000 for the Phase I effort and \$50,000 for the Phase I Option effort.** Only those Phase I efforts selected for Phase II awards through the Army's competitive process will be eligible to exercise the Phase I Option. To maintain the total cost for SBIR Phase I and Phase II activities at a limit of \$850,000, the total funding amount available for Phase II activities under a resulting Phase II contract will be \$730,000, unless Phase II - Plus funds are provided.

Companies submitting a Phase I proposal under this Solicitation must complete the Cost Proposal, Appendix C, within a total cost of up to \$70,000 (plus up to \$50,000 for the Phase I Option). Phase I and Phase I Option costs must be shown separately; however, they may be presented side-by-side on a single Appendix C. The Phase I Option proposal must be included within the 25-page limit for the Phase I proposal. In addition, all offerors will prepare an Appendix E, Company Commercialization Report, for each proposal submitted. Appendix E does not count toward the 25-page Phase I proposal limitation.

Selection of Phase I proposals will be based upon scientific and technical merit, will be according to the evaluation procedures and criteria discussed in this solicitation document, and will be based on priorities established to meet the Army's mission requirements. Due to limited funding, the Army reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality will be funded.

Proposals not conforming to the terms of this solicitation and unsolicited proposals will not be considered. Awards will be subject to the availability of funding and successful completion of contract negotiations.

### ***Phase II Proposal Guidelines***

Phase II proposals are invited by the Army from Phase I projects that have demonstrated the potential for commercialization of useful products and services. The invitation will be issued in writing by the Army organization responsible for the Phase I effort. Invited proposers are required to develop and submit a commercialization plan describing feasible approaches for marketing the developed technology. Fast Track participants may submit a proposal without being invited. Cost-sharing arrangements in support of Phase II projects and any future commercialization efforts are strongly encouraged, as are matching funds from independent third-party investors, per the SBIR Fast Track program (see section 4.5) or the Phase II Plus program described earlier under the "New This Year" section. Commercialization plans, cost-sharing provisions, and matching funds from investors will be considered in the evaluation and selection process, and Fast Track proposals will be evaluated under the Fast Track standard discussed in Section 4.3. Phase II proposers are required to submit a budget for a base year (first 12 months) and an option year. These costs must be submitted using Appendix C, Cost Proposal, and may be presented side-by-side on a single Cost Proposal Sheet. The total proposed amount should be indicated on Appendix A, Proposed Cost. Phase II projects will be evaluated after the base year prior to extending funding for the option year.

The Army is committed to minimizing the funding gap between Phase I and Phase II activities. With the implementation of Phase I Options effective with the 98.2 Solicitation, all Army Phase II proposals will receive expedited reviews and be eligible

for interim funding. Accordingly, all Army Phase II proposals, including Fast Track submissions, will be evaluated within a single two-tiered evaluation process and schedule. Phase II proposals will thus typically be submitted within 5 months from the scheduled DoD Phase I award date (the scheduled DoD award date for Phase I, subject to the Congressional Budget process, is 4 months from close of the DoD Solicitation).

### ***Submission of Army SBIR Proposals***

All proposals written in response to topics in this solicitation must be received by the date and time indicated in Section 6.2 of the introduction to this solicitation. Submit your proposal(s) well before the deadline. The Army does not accept late proposals.

**All Phase I proposals - one original (clearly marked, with original signatures) and four copies - must be submitted to the Army SBIR Program Management Office at the address below. Each copy must include Appendices A, B, and E generated and printed out by the on-line systems. All hand deliveries must be made to the Army Material Command (AMC) building mail room, located at the rear of the AMC building. Proposers should be aware that the AMC mail room hours are 0730-1530 hrs (local) and are subject to change without prior notice.**

Dr. Kenneth A. Bannister  
U.S. Army Research Office-Washington  
Room 8N31, Army Material Command Building  
5001 Eisenhower Avenue  
Alexandria, VA 22333-0001  
(703) 617-7425

### ***Electronic Submission of Appendices A and B Using the Army Website***

You must submit your Appendices A and B to the Army using the online forms. This site allows your company to come in any time (prior to the closing of the solicitation) to edit or print out your Appendices A and B. **The Army WILL NOT accept any form other than those from the Army SBIR Website as valid proposal submission forms for the Appendix A and B. Proposers must use the following procedures.**

1. Go to Internet address <http://www.aro.army.mil/arrowash/rt/> and click on "Access Phase I Electronic Submissions", then click on "Submit or Edit Phase I Appendix A and B" and follow instructions.
2. **Fill out all the information requested!** N.B.:The screen format will look different than the forms in the solicitation. Once you have filled in the data, follow the instructions to electronically save/submit appendices. That is, make sure you click on the Save/Submit button, which will save your appendices to the Army server. You will still be able to return and edit this text up to the date and time of the solicitation closing, at which time the Army will close down the site. Your electronically-submitted version should match the signed hardcopy appendices submitted with your proposal.
3. After you click on the Save/Submit button, follow instructions to print out the hardcopies of appendices and sign them. N.B.: The printed forms from the Website may look different than the forms in this solicitation book and the signature block may appear on the second page. The Army requires you to include these forms with the mailed hard copy of your proposal. Do not use any other version of the signed forms.
4. Mail the signed Appendix A, B, and E forms, along with one original and four copies of your entire proposal (the copies should include four copies of the signed Appendix A, B, and E forms) to the Army SBIR Program Management Office at the above address.

### ***Key Dates***

99.2 Solicitation Open	1 July - 11 August 1999
Phase I Evaluations	August - November 1999
Phase I Selections	November 1999
Phase I Awards	December 1999*

\* Subject to the Congressional Budget process.



### *Recommendation for Future Topics*

Small Businesses are encouraged to suggest ideas that may be included in future Army SBIR solicitations. These suggestions should be directed to the SBIR points-of-contact at the respective Army research and development organizations.

### ***Inquiries***

Inquiries of a general nature should be addressed to:

Dr. Kenneth A. Bannister  
Army SBIR Program Manager  
U.S. Army Research Office - Washington  
Room 8N31  
5001 Eisenhower Avenue  
Alexandria, VA 22333-0001  
(703) 617-7425

Dr. Robert Rohde  
Headquarters, Department of the Army  
Office of the Assistant Secretary of the Army  
(Acquisition, Logistics, and Technology)  
2511 Jefferson Davis Highway  
Arlington, VA 22202-3911  
(703) 601-1515

## **ARMY SBIR PROGRAM POINTS OF CONTACT SUMMARY**

### **U.S. Army Materiel Command**

ARDEC	John Saarmann	(973) 724-7943
ARL	Dean Hudson	(301) 394-4808
ARO	LTC Ken Jones	(919) 549-4200
AVRDEC	Brenda Haglich	(757) 878-5400
CECOM	Joyce Crisci	(732) 427-2665
ERDEC	Marvin Hohenstein	(410) 436-2855
MRDEC	Otho Thomas	(205) 842-9227
NRDEC	Gerald Raisanen	(508) 233-4223
STRICOM	Mark McAuliffe	(407) 384-3929
TARDEC	Alex Sandel	(810) 574-7545
TECOM	John Schnell	(410) 278-1478

### **U.S. Army Corps of Engineers**

COE/CERL	Carol Mihina	(217) 373-6746
COE/CRREL	Theresa Salls	(603) 646-4651
COE/TEC	Susan Nichols	(703) 428-6631
COE/WES	Phil Stewart	(601) 634-4113

### **Deputy Chief of Staff for Personnel (Army Research Institute)**

ARI	Dr. Jonathan Kaplan	(703) 617-8828
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### **U.S. Army Space and Missile Defense Command**

SMDC	Fred Clarke	(256) 955-5451
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### **Army Medical Command**

MRMC	Herman Willis	(301) 619-2471
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## DEPARTMENT OF THE ARMY PROPOSAL CHECKLIST

This is a Checklist of Requirements for your proposal. Please review the checklist carefully to assure that your proposal meets the Army SBIR requirements. **Failure to meet these requirements will result in your proposal not being considered for review or award.** Do not include this checklist with your proposal.

\*\_\_\_ 1. The Cover Sheet (Appendix A) and the Project Summary Sheet (Appendix B) are the first two pages of your proposal, and were completed using the Army's Online SBIR Proposal System (address: <http://www.aro.army.mil/arowash/rt/>). Appendix A (Page 1) clearly shows the proposal number assigned by the system to your proposal.

\*\_\_\_ 2. The proposal addresses a Phase I effort (up to **\$70,000** with up to a six-month duration) AND an optional effort (up to **\$50,000** for an up to four-month period to provide interim Phase II funding).

\_\_\_ 3. The proposal is limited to only **ONE** Army solicitation topic.

\_\_\_ 4. **The Project Summary, Appendix B, contains no proprietary information, does not exceed 200 words, and is limited to the space provided.**

\_\_\_ 5. The Technical Content of the proposal, including the Option, begins on PAGE 3 and includes the items identified in Section 3.4 of the solicitation.

\_\_\_ 6. The proposal, including the Phase I Option, is 25 pages or less in length. (Excluding Appendix E: Company Commercialization Report.) Proposals in excess of this length will not be considered for review or award.

\_\_\_ 7. The proposal contains only pages of 8-1/2" X 11" size. No other attachments such as disks, and video tapes, are included.

\_\_\_ 8. The proposal contains no type smaller than 11-point font size (except as legend on reduced drawings, but not tables).

\_\_\_ 9. The Contract Pricing Proposal (Appendix C) has been completed for **the Phase I and Phase I Option** and their costs are shown separately. The Appendix C is included as the last page of the proposal.

\_\_\_ 10. The proposal is stapled in the upper-left-hand corner, and no special binding or covers are used.

\_\_\_ 11. An original with original signatures (**clearly marked**) and four copies of the proposal are submitted.

\_\_\_ 12. **Appendix E, Company Commercialization Report, is submitted in accordance with Section 3.4.n. This report is required even if the company has not received any SBIR funding. (This report does not count towards the 25-page limit)**

\_\_\_ 13. Include a self-addressed, stamped envelope and a copy of the Notification Form (Reference A) located in the back of the solicitation book, if notification of proposal receipt is desired. **No responses will be provided if these are not included with your proposal.**

\_\_\_ 14. The proposal must be sent registered or certified mail, postmarked by August 4, 1999, or delivered to the Army SBIR Office no later than **August 11, 1999, 3:00 p.m. local time** as required (see Section 6.2). Offerors who elect to use commercial courier services do so at their own risk. The Army **can not** accept responsibility for proposals delivered late by commercial couriers.

## INDEX OF ARMY FY99 TOPICS

### U.S. Army Armaments Research, Development and Engineering Center (ARDEC)

A99-001	Hyperspectral Data Fusion
A99-002	Smart Tie-down Technology
A99-003	Innovative Non-line-of-sight Passive Acoustic Sensors for Target Location
A99-004	Automated Material-handling Equipment
A99-005	Innovative Treatment of Depleted Uranium Contaminated Soils
A99-006	Flexible Metrology for Aspheric and Conformal Optical Surfaces
A99-007	Innovative Manufacturing Designs for Energetics
A99-008	Alternative Energy Source for Illumination
A99-009	Fragmentation of Energetic Materials via Directed Ultrasonic Energy
A99-010	Miniaturized Smart Munition Concepts for the Objective Sniper Rifle

Also see OSCR Topics A99-106 thru A99-109

### U.S. Army Research Institute (ARI)

A99-011	Development and Test of a Framework for Critical Thinking Skills in a Military Context
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Also see OSCR Topic A99-110

### U.S. Army Research Laboratory (ARL)

A99-012	Lightweight Personal Protective Head Gear Communication System
A99-013	Human Communicative Performance in High Noise Environments
A99-014	Multi-modal Speech Recognition
A99-015	Laser Beam Tracking System for Optical Communication Link Between Moving Vehicle
A99-016	Speech Translation for Mobile Environments
A99-017	Monolithic Integrable Optoelectronic Devices With Variation of the Bandgap and Strain
A99-018	Hyper-spectral Terrain Understanding for an Unmanned Ground Vehicle (UGV)
A99-019	Oil-free Auxiliary Power Unit and Propulsion System Technology
A99-020	Innovative Processing of Multifunctioning Composite Armor for Ground Vehicles

See also OSCR Topics A99-111 thru A99-124

### U.S. Army Research Office (ARO)

A99-021	Production of High Energy-absorbing Metallic Foam Structural Components
A99-022	Tunable Materials for Integrated Adaptive Electronics
A99-023	Full Field Spray Diagnostics
A99-024	Novel Short Wavelength Light Source System for Portable Sensor Application
A99-025	Application of Recent Algorithm Research to ATRs in Cluttered Environments
A99-026	Digital Image Management: Integrated Computer Interfaces for Image-guided Systems
A99-027	Engineering Design Software for Military Incinerators
A99-028	Sensor System for In-situ 3D Soil Stress Analysis
A99-029	4D Remote Measurement of Tracer Concentrations for Atmospheric Dispersion Studies

See also OSCR Topics A99-125 thru A99-127

### U.S. Army Aviation Research, Development, and Engineering Center (AVRDEC)

A99-030	Innovative Methods for Evaluating Combat Performance using Full Mission Simulation
A99-031	Predictive and Real-time Visual Assessment System and Tools
A99-032	Engineering and Information System for Simulation-based Design and Acquisition
A99-033	Aerodynamic Design Tools for Advanced Rotor Configurations
A99-034	Enhanced Symbolology for Wide Field-of-View for Helmet-mounted Displays (HMDs)

See also OSCR Topics A99-128 thru A99-133

**U.S. Army Communications and Electronics Command (CECOM)**

A99-035	Mines/Unexploded Ordnance (UXO) Confirmatory System
A99-036	Landmine Detection
A99-037	Low-cost Null-steering Processor for Phased Array Antennas
A99-038	Low-cost Ethernet Encryption
A99-039	Multicast Transport Protocols for Dynamic Wireless Networks
A99-040	Display Management for Command and Control Applications
A99-041	Micro-acoustic Sensor for Future Scout Unmanned Aerial Vehicle (UAV)
A99-042	Free Space Optical Communications for Ground Tactical Applications
A99-043	Command, Control, and Communications Infrastructure Situation Awareness
A99-044	Lightweight, High-power, Ground Vehicle-mounted, Gas Turbine Auxiliary Power Unit
A99-045	Soldier's Antenna
A99-046	Unmanned Aerial Vehicle (UAV) Remote Sensor Control and Data Retrieval
A99-047	Human Computer Understanding
A99-048	Integrated Circuit and Package Switching Applications Architecture
A99-049	Low-cost Attitude and Heading Reference Systems for Phased-array Antennas
A99-050	Advanced Intrusion Detection Techniques
A99-051	Hybrid Pixel Miniaturization
A99-052	Automatic Signal Exploitation
A99-053	Rangefinder/Illuminator Read-Out Integrated Circuit (ROIC)
A99-054	Laser Protection Device for Near Infrared (IR) Optical Devices
A99-055	Solid State Infrared (IR) Chopper for Uncooled Infrared Camera

See also OSCR Topics A99-134 thru A99-145

**U.S. Army Cold Regions Research and Engineering Laboratory (CRREL)**

A99-056	Preflight Deicing and Anti-icing of Helicopters
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**U.S. Army Chemical Biological Center of Excellence (CBCOE)**

A99-057	Synthetic Receptors for Reagentless Biosensors
A99-058	Microfabrication-based Biodetectors

See also OSCR Topic A99-149

**U.S. Army Missile Research, Development, and Engineering Center (MRDEC)**

A99-059	Small, Low-cost GPS Anti-jam System
A99-060	Liquid Crystal Polymer as a High-density, High-reliability, Electronic Substrate Material
A99-061	Alternative Liner Materials for Main Charge Warheads
A99-062	Internet Solutions for Information Integration
A99-063	Object Tracking through Rapid Sensor Orientation Change

See also OSCR Topics A99-150 thru A99-156

**U.S. Army Medical Research and Materiel Command (MRMC)**

A99-064	Environmental Recording for Monitoring Soldiers Wearing Head-mounted Devices
A99-065	Systems for Improved Manufacture of Human Fibrinogen
A99-066	Attractant/Insecticide to Eliminate Transmission of Tick- and Chigger-borne Diseases
A99-067	Biological Agent Sample Preparation for the Detection and Identification of Multiple Agents by Nucleic Acid-based Analysis
A99-068	Non-invasive Pneumothorax Detection for High-noise Environments



A99-069	Interrogatable Micro-environmental Sensor Pod for Dismounted Infantry
A99-070	Portable Oxygen Generators
A99-071	Systems for Improved Homeostasis
A99-072	Novel procedures for determination of Immunologic Consequences of Repeated exposures of Homologous Cholinesterases in Nonhuman Primates
A99-073	CANCELLED
A99-074	Non-intrusive Lactate Sensor
A99-075	Blast Mitigation Jacket for Training
A99-076	Non-invasive, Lightweight Cardiac Output Detection for Use in the Battlefield and High Noise Environments
A99-077	Stabilization of Critical Reagents

#### **Natick Soldier Center (NSC)**

A99-078	Nanotechnology for Ballistic Protection
A99-079	Novel Forming Techniques of Complex Shapes in Personnel Armor

See also OSCR Topics A99-157 thru A99-160

#### **U.S Army Space and Missile Defense Command (SMDC)**

A99-080	Common Sense Reasoning to Locate Threats
A99-081	Mitigation of Magnetohydrodynamic Electromagnetic Pulse Effects on Long Lines for Missile Defense System and Infrastructure Protection
A99-082	Combine Auditory/Olfactory Sensory Immersion for Decision Support
A99-083	High-energy Laser Optical and Diagnostic Development

See also OSCR Topic A99-161

#### **U.S. Army Simulation, Training, and Instrumentation Command (STRICOM)**

A99-084	Distributed Collaborative Java-based Positioning Instrumentation Modules
A99-085	Advancements in Individual Combatant Simulation Technology

See also OSCR Topics A99-162 thru A99-164

#### **U.S. Army Tank, Automotive, and Armament Research Development and Engineering Center (TARDEC)**

A99-086	Compression Ignition Engine Technology Insertion
A99-087	Smart Lead Acid Batteries for Starting, Lighting, and Ignition Applications
A99-088	Advanced Opposed-piston 2-stroke Diesel Demonstrator
A99-089	Surfactant Resistant Fuel Filtration
A99-090	Semiactive Shock Absorber for HMMWV
A99-091	Sensor Technology for Detecting and Monitoring Corrosion of Land-based Vehicles
A99-092	Computer Modeling the Corrosion and Durability of Land-based Vehicles
A99-093	Hyperspectral Evaluation of Signature-managed Materials
A99-094	Mine-resistant Track Development
A99-095	Portable Fuel Analyzers
A99-096	Smart Structures for Combat Ground Vehicles
A99-097	Video Compression for Standard Teleoperation Kits
A99-098	Recycling of Discarded Rubber Tires

See also OSCR Topic A99-165

#### **U.S. Army Topographic Engineering Center (TEC)**

A99-099	Semantic Mapping Tools
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See also OSCR Topic A99-166

#### **U.S. Army Test and Evaluation Command (TECOM)**

A99-100	Remote Autonomous Zoned Optical Range
A99-101	Solid State Oxygen Concentration Measurement System
A99-102	Ordnance Detection

See also OSCR Topic A99-167

#### **U.S. Army Waterways Experiment Station (WES)**

A99-103	Device for Measuring Response of Windows and Window Retrofit System
A99-104	Bistatic Radar Measurements and Inversion Modeling
A99-105	Miniature Blast Sensors for Conventional Weapons Effects Studies

#### **Topics Addressing U.S. Army Operating and Support Cost Reduction (OSCR) Initiatives**

#### **U.S. Army Armaments Research, Development and Engineering Center (ARDEC)**

A99-106	Innovative Structural Control and Devices using Smart Material Technologies
A99-107	Intelligent Multi-agent Hybrid Systems Control Technology
A99-108	Proficient Gun Barrels
A99-109	Acoustic Mine Detection and Neutralization

#### **U.S. Army Research Institute (ARI)**

A99-110	Training Adaptability in Digital Skills
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#### **U.S. Army Research Laboratory (ARL)**

A99-111	Micromagnetic Sensor Technology
A99-112	Logistics Site Planning and Operation Tool (LOGSPOT)
A99-113	Novel Wear Resistant and Thermally Insulative Materials
A99-114	Smart Materials for Collapsible Fuel and Water Storage Tanks
A99-115	Low-cost, Adhesiveless Method for Assembling Fibrous Preforms
A99-116	High-mobility Trailer
A99-117	Energetic Materials for Batteries and Electrochemical Capacitors
A99-118	Sampling Sensors for Monitoring Hazardous Gaseous Combustion/Pyrolysis Chemicals
A99-119	Low-cost Fabrication Technologies to Produce Transparent Armor Ceramics
A99-120	Compact, High-power Microwave Antenna
A99-121	Wavelength Division Multiplexing Fiber Optic Microwave Delay System
A99-122	Time-efficient, High Rate Production and Manufacturing for Nanoparticulates
A99-123	Direct Digital Synthesis Technology
A99-124	Real-time Image Restoration Processor

#### **U.S. Army Research Office (ARO)**

A99-125	Hybrid Power Systems in the 10-50 Watt Power Range
A99-126	Enhancements to Hand-held Detectors for Unexploded Ordnance and Landmine
A99-127	Ammonia-based Hydrogen Sources for Small Fuel Cells

#### **U.S. Army Aviation Research, Development, and Engineering Center (AVRDEC)**

A99-128	Dual-alloy Technology for Turboshaft Engines
A99-129	Aircraft Engine and Transmission Wear Monitoring Sensor
A99-130	Lightweight Double Helical Gears for Aerospace Applications
A99-131	Battle Damage/Fault-tolerant Reconfigurable Open Systems Avionics Architecture
A99-132	Graphics Display Systems for Night Vision Goggles (NVG)
A99-133	Affordable Fuel System Computer

**U.S. Army Communications and Electronics Command (CECOM)**

A99-134 Low-cost Helicopter Collision Warning System  
A99-135 Radio Frequency Communications Modeling using Distributed Simulation  
A99-136 Near Real-time Radio Frequency Emitter Mapping  
A99-137 Low-cost Modular Intelligence System  
A99-138 Physically Small, Very High-frequency/Ultra-high Frequency Conformal Antennas  
A99-139 Tactical Vehicle Inverter System  
A99-140 Lightweight Integrated Navigation and Communications Radio System  
A99-141 Application of Distance Learning to Training for Logisticians and Command Post XXI  
A99-142 Electrooptic Active Ambient Attenuator  
A99-143 Innovative Backlight Technologies for Miniature Active Matrix Liquid Crystal Display  
A99-144 Dual-voltage, Multiconfigurible Nonrechargeable Battery Design with Adapter  
A99-145 Speech Intercept Intelligibility for Spectrum Supremacy

**U.S. Army Construction Engineering Research Laboratory (CERL)**

A99-146 Asbestos Neutralization by In-situ Chemical Digestion  
A99-147 Magnetic Fluxgate Micro-electromechanical Systems (MEMS) for Structural Integrity  
A99-148 Artificial Intelligence (AI) for Identifying Pavement Defects From Visual Image Data

**U.S. Army Chemical Biological Center of Excellence (CBCOE)**

A99-149 Self-contained Surface Bio-sampling Apparatus

**U.S. Army Missile Research, Development, and Engineering Center (MRDEC)**

A99-150 Novel Imaging Techniques for Compact Aerial Vehicles  
A99-151 Alternative Communications for Nonline-of-sight Applications  
A99-152 2D High-speed Bipolar Optical Modulator Array  
A99-153 Enhanced Scramjet Combustion  
A99-154 Steerable Array Antenna using Micro Electro Mechanical Switches (MEMS) Technology  
A99-155 An Effective Mixing Process for Gelled Propellants  
A99-156 Spatial Antenna Arrays/Processing for C3 with Unmanned Ground Vehicles (UGV)

**Natick Soldier Center (NSC)**

A99-157 Onsite Packaging and Food Waste Disposal (Safe Incineration)  
A99-158 Portable Rapid Analytical Technology for Food Safety  
A99-159 High-speed/Low-cost Impermeable Seaming for Synthetic Tentage and Collective Protection Shelters  
A99-160 Human Performance Modeling of Paratrooper Landings

**U.S. Army Space and Missile Defense Command (SMDC)**

A99-161 Fluorine and other Extremely Hazardous Chemicals Gas-handling Equipment

**U.S. Army Simulation, Training, and Instrumentation Command (STRICOM)**

A99-162 Robust, Low-cost Target System Data Link  
A99-163 Software Tools for Visualization of Terrain Databases  
A99-164 Multi-resolution Modeling

**U.S. Army Tank, Automotive, and Armament Research Development and Engineering Center (TARDEC)**

A99-165 Unique Hardkill Active Protection Countermeasures Mechanisms

**U.S. Army Topographic Engineering Center (TEC)**

A99-166 Methods for Achieving Improved Position and Orientation Performance from Small, Low-cost Sensors

**U.S. Army Test and Evaluation Command (TECOM)**

A99-167                      Marrying Commercial-off-the-shelf (COTS) and Government-off-the-shelf (GOTS) Equipment for Tracking Chemical Releases

## ARMY FY99 TOPICS

### U.S. Army Armaments Research, Development and Engineering Center (ARDEC)

A99-001                      TITLE: Hyperspectral Data Fusion

TECHNOLOGY AREA: Sensors, Electronics, and Battlespace Environment

OBJECTIVE:                To miniaturize the electronics that implement algorithms used in hyperspectral data fusion.

DESCRIPTION: Algorithms developed for and by the Army for fusing hyperspectral data act on intensity measurements (pixels) of 16 bit integers stored in three dimensional arrays where two dimensions (of less than or equal to 512 x 512 pixels) are spatial and the third (of less than or equal to 256 values) is spectral. The algorithms involve match filtering (functions of 256 - 16 bit integer values or less) and convolution of determinable functions (functions of up to 64 x 64 x 256 - 16 bit integer values) with the data. Examples might include the response function of the human eye or a least squares matching to a spectral function representing vegetation. Data processing throughput can be greater than one giga-pixel per second. Current implementation of hyperspectral processing entails use of massive amounts of costly electronics including field programmable gate arrays (FPGA). With the required supporting electronics, FPGAs are considered too bulky to be a solution.

This solicitation is for custom hardware which can fit into as small a volume as possible( 6 cubic inches maximum) to process the data. The hardware must include data storage for the raw data, and intermediate and final results. The hardware needs to interface to input channels and output channels commensurate with the data rates mentioned.

PHASE I: Design and simulate the electronics for the operation. An application specific integrated chip is anticipated.

PHASE II: Fabricate, test and deliver the electronics. Several fabrication and testing iterations to perfect the electronics should be anticipated.

PHASE III DUAL-USE APPLICATIONS: Hyperspectral imaging has many applications. The field is just starting to grow. Fast, small, and generic processing chips are required before the full benefit of this field will be experienced. Applications include hyperspectral infrared imaging, hyperspectral x-ray, and data fusion in general. Specific applications are military target identification and classification, battlefield damage assessment, friend or foe discrimination, non-destructive inspection, smart munitions, medical diagnostics, and smart cars.

KEYWORDS: data fusion, hyperspectral imaging, hyperspectral, ASIC, VLSI, match filtering, convolution, data processing, algorithms.

REFERENCES: "Real-Time, PC Based Color Fusion Displays," J. Waterman, et.al., presented at 1999 IRIS Specialty Group on Passive Sensors Conference, Web site: <http://www-datafusion.cma.fr/>

A99-002                      TITLE: Smart Tie-down Technology

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop an advanced materials grid matrix which enables munitions and other cargo to be rapidly secured or unsecured to a 20 foot long by 8 foot wide steel shipping platform.

DESCRIPTION: The Palletized Load System (PLS) is composed of a prime mover truck with integral self-loading and unloading capability, a 16.5-ton payload trailer, and demountable cargo beds (flatracks). The PLS is the U.S. Army's key transportation component of the ammunition distribution system. It will perform long range hauling, local hauling and unit resupply of ammunition. Currently a new flatrack for the PLS, the Container Roll-in, Roll out Platform (CROP), is being fielded. The CROP will provide the Army with new capability - a direct link between commercial transportation systems and battlefield distribution systems. However, although the CROP will speed up the movement and delivery of munitions it has one flaw. The method for securing munitions and cargo to the CROP takes too long and is too labor intensive. Securing ammunition or cargo to the CROP involves 12 nylon straps with ratchets and wood blocking and bracing. Completing this tie-down procedure takes two or three soldiers 15-20 minutes to complete. The procedure takes this long because the soldiers must adhere to specific

strapping guidelines to make the load safe for transport. These strapping guidelines, while nice to follow in peacetime, are highly impractical in a wartime situation. CROP loads will constantly be altered, therefore trying to find strapping procedures for every possible combination will be highly impractical. The future methodology for securing and un-securing munitions to the CROP must be improved. Tomorrow's technology can provide such an improvement. A grid matrix using bio-materials (spider silk) or rigid polyurethane foams would provide great strength, low weight, and flexibility. Production costs for the matrix must prove to be comparable to the production costs for standard strapping systems. The grid matrix must also provide a rapid and automated self-tightening capability to assure the munition load is securely and rigidly fastened to the CROP. Optical or electrical sensors embedded in the matrix provide self-adjusting characteristics under various loading conditions. Potential applications of the grid matrix are unlimited. This program will also explore ways of using the grid matrix to secure cargo on Army tactical cargo trucks (i.e., 2.5 ton, 5 ton, 10 ton) and trailers (i.e., M871 - 30' and M872 - 40' trailers), as well as commercial 20' and 40' trailers.

PHASE I: Develop the overall approach, design and functionality of the grid matrix. Investigate and assess the utility of biomaterials, rigid polyurethane foams, sensors and other materials for the matrix. Select an optimum material and develop concept drawings. Demonstrate the concept by small-scale model or Computer Aided Design. The model or design will illustrate the integration of all subsystems, or show individual subsystems and how they meet final design requirements.

PHASE II: Develop, assemble and demonstrate a prototype system. The system will be inserted into a realistic environment with Army supplied inert munitions and other cargo types. Testing of the design will be performed at the Army's National Training Center. After testing the design will be enhanced or modified to incorporate needed changes.

PHASE III DUAL-USE APPLICATIONS: The technology developed under this program would have widespread application to the commercial logistics, cargo, and package shipping industry. It would provide tremendous cost savings in reduced manpower currently required to secure cargo and packages to tractor-trailer beds, trucks, railcars, aircraft 463L pallets, and logistics shipping platforms.

KEYWORDS: Smart Tie Down Technology, Cargo containers, Weapon Pallets, Automated Handling, Advanced Materials

A99-003 TITLE: Innovative Non-line-of-sight Passive Acoustic Sensors for Target Location at Extended Ranges

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Determine methods or Improvements to Increase Target Location Determination/Bearing Accuracy for Acoustic Sensors at Extended Ranges

DESCRIPTION: The Army needs intelligent acoustic sensors for battlefields of the 21st century. These needs include battlefield surveillance, situation awareness and cueing for other sensors. As a result of these needs, the demand for improved acoustic sensor performance has also increased. One of the operational requirements pushed in acoustic sensors is to increase the range for target detection. However, the complexity of the acoustic propagation environment and the extreme diversity of combat operations under which acoustic sensors may be employed have caused sensors to perform with accuracy errors of 2 to 3 degrees at best. Consequently, as the sensors detection ranges increase to 5-6KM, the target location/bearing error also increases in proportion. For example: 3 degrees of bearing error at 2 Km is 105m vs 3 degrees of bearing error at 6Km equals 314m. Therefore, proposals are invited to develop innovative methods or techniques to improve acoustic sensor performance in target location determination/ bearing accuracy considering atmospheric conditions and terrain at extended ranges with the following considerations: 1. Conventional and adaptive beamforming techniques 2. Sensor array designs (Battlefield application must considered) 3. Fusion of integrated sensors/sensor arrays with overlapping coverage. 4. Innovative detection methods or techniques to increase detection range and/or resolution, e.g., wave guide, passive signature relay to modulate signature data from a node (or nodes) to a sensor, etc.

PHASE I: Develop an overall method (or technique) design in block-diagram form that includes specifications of how to enhance acoustic detection considering atmospheric conditions and terrain at extended ranges with high resolutions. This phase will illustrate the contractor's understanding of the requirements, appropriateness of the approach, and expectation of meeting the Phase II objectives. During this phase the detection range of environmental conditions, terrain features, sensor characteristics, and target arrays will be defined.

PHASE II: During this phase the detection range of environmental conditions, terrain features, sensor characteristics, and target arrays will be defined.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to determine the feasibility over extended operating conditions.

PHASE III DUAL-USE APPLICATIONS: Employment of acoustic sensors for intrusion detection/tracking, such as large storage area depots, border surveillance, or monitoring of wilderness areas to detect unauthorized activity, have the same general requirements. These non-defense applications also desire increases in detection range capability to improve the overall

sensor effectiveness. Phase III opportunities exist for extended range capability wherever intelligent acoustic sensors are employed.

REFERENCES: Battlefield Acoustic Sensor Integration System (BASIS), Principal Investigator/Author: David C. Swanson, Applied Research Laboratory, Pennsylvania State University, 1 May 1996, Final Report (Phase I) to Mr. Ted Saffos at Naval Surface Warfare Center Dahlgren Division.

KEYWORDS: acoustic sensors, target location, beamforming techniques, sensor fusion

A99-004                    TITLE: Automated Material-handling Equipment

TECHNOLOGY AREAS: Ground and Sea Vehicles

OBJECTIVE: Develop a low cost hybrid sensor suite providing an automated pallet acquisition capability thereby removing the need for a ground guide during munitions resupply operations.

DESCRIPTION: Significant progress has been made in developing advanced teleoperated control systems for generic wheeled or tracked vehicles. Specifically, a standardized teleoperation system (STS) has been developed for driving these vehicles without a man at the wheel. The ATLAS forklift is essentially a teleoperated material handling carriage caused by the obscured view the operator has of the end effector. This partial view of the workspace requires the presence of a ground guide as an aid in performing munitions resupply operations. A need exists to provide positional information of the immediate workspace environment and decision aids enabling the driver to perform the required operations without the need of a ground guide or any other personnel in the local vicinity. The target platform will be the ATLAS, a 10,000 pound payload rough terrain forklift with an extendable boom designed for stuffing and unstuffing 20 foot ISO containers as well as standard forklift operations. The material handling system can be reduced to a 6 degrees of freedom (DOF) manipulator that must be precision controlled to execute all tasks defined by the systems operational envelope. To fulfill this requirement technical issues of mobility and base motion effect, knowledge based/flexible task level control, multi-sensor integration, path planning, navigation and obstacle detection/avoidance must be balanced against passive solutions such as vision blocks, tactile antennae and light tubes etc. to attain real time performance. Also, a standardized software development environment must be used to generate the algorithm implementation required for system operation.

PHASE I: Develop methodology and algorithmic approaches for automatic control of the material handling carriage for applications of palletized munitions handling and compare these capabilities to that of a passive low cost system. Perform preliminary modeling and simulation studies to determine performance/robustness characteristics of the control laws and algorithms, real time processing and sensor requirements. Provide analysis for evaluating control laws and provide control processor design and system hardware specifications.

PHASE II: Develop controller hardware/software and development environment for interface with the forklift system. Develop low cost passive solution prototype for field test. Develop test scenarios to demonstrate controller performance and integrated system capabilities. Provide fully instrumented prototype vehicle system with operators control station, documented source code, development environment and complete operators manual suitable for training non-technical personnel for evaluation exercises.

PHASE III DUAL-USE APPLICATIONS: The technology developed under this program can be utilized on any commercially available forklift style material handling equipment (MHE). The technology is also applicable to automated warehousing, rail head and port operations, handling of hazardous materials, security, counter terrorism and law enforcement.

KEYWORDS: automated equipment, forklift, ISO containers, material handling, control technology

A99-005                    TITLE: Innovative Treatment of Depleted Uranium (DU) Contaminated Soils

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To conduct research in the area of organic based emulsions and their application to in-situ stabilization of DU contaminated soils for both the purpose of site remediation as well as for on-going maintenance of operational DU firing ranges. This work will include a laboratory treatability study/proof-of-principal demonstration as well as a field trial.

DESCRIPTION: Uranium is an extremely dense metal used in kinetic energy penetrators and tank armor. DU contains isotopes found in natural Uranium, but the radioactive components are in much lesser concentrations. Over the past twenty years, the

Department of the Army has developed, tested and fielded a number of weapon systems containing DU. Other services (i.e., Air Force, Navy, etc.) have also engaged in similar programs. DU contaminated soil at test facilities poses potential health risks due to DU migration via multiple pathways. The extent and significance of the potential health risks are the subjects of ongoing studies by the Army. The main methods of migration are either movement due to wind, water erosion, dissolution or suspension of DU containing particles in runoff, and percolation through the soil (leaching). A treatment method must therefore prevent DU from potentially leaching to groundwater and from surface migration due to wind and water erosion. Existing remediation methods include excavation, bulk treatment and off-site disposal, which is extremely expensive, and bioremediation, which is time consuming and requires specific soil types. None of these methods provide a cost-effective method for ongoing maintenance of an active firing range. The highly regulated nature of DU, combined with public perception of health risk, create pressure to address the problem. Additionally, in order for needed testing of DU weapons to continue, on-site waste materials must be properly managed in order for the test facility to remain within the operating limits of its Nuclear Regulatory Commission license. Hence, Army readiness relies upon the development of practical, cost-effective cleanup and ongoing maintenance strategies.

PHASE I: Demonstrate proof of principle of an emulsion-based system's ability to chemically and physically immobilize the DU in soil. Conduct laboratory analysis to evaluate the reduction in leaching potential of treated soil and determine its durability and resistance to mechanical migration. Evaluate the optimal treatment procedures and anticipated remediation effectiveness. This initial evaluation should also include recommended equipment and construction methodologies for in-situ processing of impacted soils, all equipment and materials necessary to scarify and treat the impacted areas, and the requirements for an on-going range maintenance program.

PHASE II: Design and conduct an actual field demonstration of the proposed stabilization system. This would include multiple test sections to determine effective application methods and rates. These test sections would also be used to evaluate the system's ability to control the spread of particulate matter by wind action or mechanical means and would be designed to validate preliminary cost estimates and provide information necessary for full deployment..

PHASE III DUAL-USE APPLICATIONS: This concept would have multi-Service application as well as widespread DoE usage. With disposal costs for DU contaminated soils well in excess of \$1500 per ton, and contaminated soils on Army sites alone conservatively estimated at several hundred thousand tons, tremendous opportunities exist to save substantial money. Significant international interest is also forecast. The United Kingdom, Russia, Turkey, Saudi Arabia, Pakistan, Thailand, Israel, France and others are developing or already have DU-containing weapon systems. This approach could also have application to provide effective remediation and/or containment after battlefield operations (i.e., Desert Storm).

KEYWORDS: depleted uranium, contaminated soils, low level radionuclides, migration pathways

A99-006 TITLE: Flexible Metrology for Aspheric and Conformal Optical Surfaces

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Design and build a prototype device capable of rapid precision measurement of aspheric, non-axially symmetric, and conformal optical surface figures to sub-wavelength accuracy without the need for a customized diffractive optical element or any customized reference.

DESCRIPTION: Recent Opticam optics manufacturing technology developed by the Center for Optics Manufacturing (COM) enables economic fabrication of aspheric surfaces in optical glasses and brittle materials as well as conformal optical surfaces of various symmetries or even non-symmetry. Although the figure of conic surfaces can be characterized by conventional interferometer geometries, aspheric surfaces described by up to tenth order polynomial terms in many cases require the fabrication of a diffractive optical element as a reference. Off-axis aspheres and conformal optics comprise a further challenge. Thus, a process which requires negligible setup and does not require special tooling suffers delays, extra cost and limitations due to metrology for acceptance. Touch probe methods are slow, suffer from sampling limitations and require physical contact with the optic. This program will develop an economic, rapid, flexible technique and device for measurement of these surfaces without customized reference elements. Goals are measurement of 100mm diameter surfaces (specular and non-specular) with 500 microns departure from a best fit sphere to an accuracy of 0.1 micron. Capability to make in-process measurements on the Opticam Aspheric Generator, enabling closed loop control, is desirable. Applicability to tangent ogive and off-axis aspheres is desirable. Non-contact methods are preferable.

PHASE I: Coordinate with COM to establish performance and environmental parameters required for metrology system to interface with Opticam Asphere and Opticam Conformal generation and polishing equipment. Design metrology system for measurement of non-spherical surfaces. Demonstrate proof-of-principle of design by measuring aspheres with departures of 50 microns with a brassboard system.



PHASE II: Develop and demonstrate a prototype metrology system. First demonstrate operation with conic aspheric surfaces (500 micron departure) typical of Opticam post-generation and post-polishing stages. Verify accuracy by comparison with conventional interferometry. Demonstrate system by measurement of complex aspheres (500 micron departure) with up to tenth order polynomial descriptions and slope reversal. Apply measurement technology to conformal optical samples from Opticam machinery. As before, this will be performed for surfaces from post-generation and post-polished surfaces.

PHASE III DUAL-USE APPLICATIONS: Aspheric and conformal optics will impact military optical and electro-optical systems (e.g., helmet mounted displays, avionics) by reducing weight and size and improving performance. They will be used in commercial systems for cinematography, medical endoscopy, photolithography, thermographic imaging.

REFERENCES: D. Golini et al., Precision optics fabrication using magnetorheological finishing, Proc. SPIE Vol. CR67, p. 251-274, Advanced Materials for Optics and Precision Structures, Mark A. Ealey; Roger A. Paquin; Thomas B. Parsonage; Eds. (Sep 97) 2. D. Golini et al., Fabrication of glass aspheres using deterministic microgrinding and magnetorheological finishing, Proc. SPIE Vol. 2536, p. 208-211, Optical Manufacturing and Testing, Victor J. Doherty; H. Philip Stahl; Eds. (Sep 95)

KEYWORDS: Aspheric optics, conformal optics, flexible metrology, electro-optical systems

A99-007 TITLE: Innovative Manufacturing Designs for Energetics

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Generate data and demonstrate the ability to determine the concentrations of ingredients of energetic formulations including gun propellants, explosives, solid rocket fuels, pyrotechniques and their degree of mixedness (spatial distribution) during manufacturing on an on-line or in-line basis and close to real-time so that energetic grains which do not meet specs can be immediately identified and recycled during manufacture.

DESCRIPTION: Most manufacturing operations for energetics are moving towards continuous processing technologies including twin screw extrusion. In continuous processing, multiple ingredients are fed separately and intermixed, molten, pressurized and shaped into grains within the confines of a single extruder. TACOM - ARDEC is one of the leading centers in this area having recently demonstrated live continuous processing of PAXIIA explosives at Picatinny Arsenal, NJ. Continuous processing is ideal for manufacturing flexibility and the ability to process the new generations of extremely viscous, solventless thermoplastic-elastomer-based energetic formulations. However, the continuous processing may suffer from lapses in accurate feeding of various ingredients and occasional migration, stagnation and pipe line effects which may generate variations in concentrations of ingredients in processed grains, which may lead into variations in burn rate. In the era of smart weapons such variations are not acceptable. Currently there are no technologies which can economically, on-line and in real-time determine the variations in concentrations of various ingredients and the statistics of their spatial distributions within each grain. The ability to accomplish this can increase the quality of energetics tremendously while decreasing the testing time, reject rates, costs and environmental impact.

PHASE I: The Phase I will culminate in innovative manufacturing designs which will accurately reveal the spatial distribution and concentration of ingredients on a real-time basis. The capability of the method to being used on-line should also be demonstrated by a design study.

PHASE II: Develop and demonstrate a prototype system to determine the concentrations of various ingredients of live formulations and the statistics of their spatial distributions (degree of mixedness) in a realistic production environment. The Phase II should result in the demonstration of the system on one live formulation as part of the twin screw extrusion facility available at Picatinny Arsenal. PHASE III - Dual Use Applications: The technology of on-line and in near real-time analysis of concentrations of ingredients in a processed suspension or dispersion and their degree of mixedness is of interest to multiple industries including pharmaceutical, food, ceramic, magnetic, construction and composite industries. The technology will find widespread use as a quality control and process sensor device.

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5. " R. Yazici and D. Kalyon, " Degree of Mixing Analysis of Concentrated Suspensions by Electron Probe and x-ray Diffraction", Rubber Chemistry and Technology, 66, 4, 527-537 (1993).

6. R. Yazici and D. Kalyon, Journal of Energetic Materials, "Quantitative Characterization of Degree of Mixedness of LOVA Grains", Journal of Energetic Materials, 14, 57-73 (1996).

KEYWORDS : Sensing, on-line, real time, concentration, energetics

A99-008 TITLE: Alternative Energy Source for Illumination

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: To develop a state of the art, non radioactive , non chemical, self powered illumination system.

DESCRIPTION: This innovative illumination system will provide sufficient energy for low level illumination and it is desired to have a five year service life with enough power for 4 hours of continuous operation. It will be environmentally friendly replacing the current radioluminescent illumination systems used in the U.S. Army's fire control instruments such as the fire control scales, level vials, reticles etc. It is also desired that the system be free of chemical batteries and that the system power source be able to provide low level electrical power for small electronic devices.

PHASE I: Assess state of the art technologies and then develop innovative designs which will result in a long life, non radioactive/chemical, self powered illumination system. The focus will be conducting energy conversion studies to analyze new power source concepts and concepts for low level illumination to produce conceptual designs for the illumination system.

PHASE II: An optimal conceptual , self powered illumination system will be selected based on an analysis of the identified design studies from Phase I. Critical enabling technologies and hardware will be identified to support fabrication of the illumination system. A working model of the selected concept will be fabricated with the goal to demonstrate feasibility of the illumination system.

PHASE III DUAL-USE APPLICATIONS: The AESFI could provide low power illumination for portable electronic devices used with cellular phones, passenger aircraft, arctic and desert installations where chemical battery powered systems don't work for very long and may be unsafe. The AESFI could also provide temporary low light emergency exit illumination, in homes, industry, aircraft etc., where normal power may become interrupted. It could also provide safer, low cost illumination of military fire control devices used with small arms, mortars, artillery and tanks.

KEY WORDS: Fire Control Illumination, Tank, Artillery, Mortars, Non Radioactive, Self-Generating, Self Powered, Small Arms

OPERATING AND SUPPORT COST (OSCR) REDUCTION. Since the AESFI will be designed with no or minimal regulatory requirements or controls, administrative and service requirements, it would have the potential to reduce significantly the current weapon system operating and support costs which accounts for up to 30% of the weapon life cycle costs. The Army is now requiring that its chemical battery costs be reduced by 50% for its weapon systems. The AESFI will contribute to this battery reduction mandate. It will also reduce the costly disposal and regulatory burdens.

A99-009 TITLE: Fragmentation of Energetic Materials via Directed Ultrasonic Energy

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and demonstrate technology which applies ultrasonic energy to explosives which have been cast-loaded (e.g., TNT, Composition B) in medium and larger caliber ammunition. The objective is to cause in-situ controlled fragmentation. This will enable safe, efficient removal and recovery of the energetic material as well as recovery of the metal parts during demilitarization (demil) operations.

DESCRIPTION: The US stockpile of unserviceable and obsolete munitions currently exceeds 500K tons. A significant portion of this inventory is made up of medium and large caliber ammunition loaded with TNT and Composition B. Historically, demilitarization of this ammunition has been carried out by open detonation although more recently, demil via autoclaving has been employed in order to recover energetic material and metal parts. While autoclaving is effective, the process is labor intensive (and thus costly with operators put at some risk) and also generates pink water that must be processed as a hazardous waste. It is known that when high intensity ultrasound is applied to a liquid medium within the presence of solids, the stress produced by "acoustic cavitation" in the liquid caused fragmentation of the solid. The stress (or pressure) produced by the cavitation of the liquid is a function of the properties of the liquid. High vapor pressure and surface tension are beneficial. It is proposed to use these principles to develop a process to remove and recover cast-loaded explosives from the interior of

projectiles. Previous research has demonstrated the feasibility of such an approach through experiments conducted on TNT and Composition B simulants. The proposed project will build on this initial work and use live energetic material to establish a process followed by parametric studies to investigate process performance and develop an optimized pilot process.

PHASE I: Carry out laboratory testing to establish baseline parameters for the fragmentation of energetic material via ultrasonic energy. Experiments will first be conducted in explosive-filled 100 ml beakers and concentrate on the sonication liquid's properties and ultrasonic power effects. Methods to remove the fractured energetic material from the solid/liquid interface and separation from the sonication liquid will also be studied. Where appropriate, computer modeling will be used to study process phenomena and evaluate parameter interactions. The extent of material heating due to input of ultrasonic energy will be assessed. A preliminary process flowsheet and material balance will be developed.

PHASE II: Based on the preliminary process developed in Phase I, a pilot scale process will be developed, evaluated and optimized. Rate of fragmentation, yield of recovered energetic material and recycle of the sonication liquid will be maximized. Actual munitions items (e.g., 60mm, 81mm and 105mm projectiles) will be used in the pilot process demonstration, and design data sufficient to allow scale-up to a prototype demilitarization process will be generated.

PHASE III DUAL-USE APPLICATIONS: In the area of demilitarization, this technology has application to many different munitions. In the private sector, this technology could be used in the process industries to dislodge scale and other foreign material build-up from the interior of process piping.

REFERENCES: 1. Baum, J. and Baum, K., Explosive Removal Using Ultrasonic Energy, Contractor Report ARWEC-CR-97003, US Army Armament Research, Development and Engineering Center, Picatinny Arsenal, NJ, March 1997.

KEYWORDS : Ultrasound, explosives, demilitarize

A99-010 TITLE: Miniaturized Smart Munition Concepts for the Objective Sniper Rifle

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Substantially improved hit probability, miniaturized components, reduced weight and increased effective range for the Objective Sniper Rifle

DESCRIPTION: Current sniper rifles are conventional guns using standard kinetic energy bullets augmented with optical sights and occasionally laser rangefinders. Due to increased lethality and range requirements, it is necessary to seek technology improvements in many areas. These include innovative smart munitions, trajectory correction mechanisms, light weight and miniaturized components, crosswind sensors, control links, laser hardened optics, etc. It is envisioned that through these innovative sensors, lightweight construction, miniaturized components, and innovative trajectory altering mechanisms, the smart munition will be able to detect a target from a set of targets, to lock onto the target if it moves, and to be able to incapacitate the target without hurting innocent bystanders.

PHASE I: Identify promising technologies and processes that will provide for improved performance of these weapons. Conduct modeling and simulation studies of the selected devices/components using an approved set of engagement metrics (range, position, velocity, time). If possible build and test a breadboard.

PHASE II: Provide the design of the device(s)/components from Phase I and test for functionality and verify performance by simulation. Fabricate one or more optimally designed devices/components and test for actual performance.

PHASE III: This technology has commercial applications for law enforcement agencies, the hunting rifle markets and other dual-use applications. Law enforcement agencies can use this smart munition concept to pick out a particular target from a class of targets, lock onto a moving target, and incapacitate without hurting innocent bystanders. Individual components of this Smart Munition will require electrical power and higher energy density batteries which have application to small devices such as radios, cameras, calculators, etc. The envisioned munition sensor must pick out not only a class of targets, but also one particular target from a class of targets. This sensor could be applied to robotic assembly where similar components with minute, distinguishing characteristics can be discerned. The envisioned maneuver mechanism could use materials which can bend when voltages are applied; and this technology could have medical applications for prosthesis. Composite materials which can lighten the munition could have applications to bicycles, automobiles and aircraft, etc. All of these technologies can be adapted to the commercial market for hunters. Modern hunting rifles could be made more accurate and lightweight as well.

KEYWORDS : Smart munitions, sniper rifles, modeling and simulation, trajectories, miniaturized components, hit probabilities

U.S. Army Research Institute (ARI)

## TECHNOLOGY AREAS: Human Systems

OBJECTIVES: Develop a conceptual model to integrate critical thinking skills, knowledge, attitudes, other relevant cognitive variables, battle command tasks, and battle command performance within the context of the military decision making process; Apply the model to the training of selected critical thinking skills.

DESCRIPTION: Increased attention is being paid in the Army to training critical thinking skills to improve performance on military decision making procedures. However, efforts in this area have been theoretically fragmented and characterized by unsubstantiated claims that training specific critical thinking skills will improve battle command performance. If progress is to be made in training such skills, a more systematic approach is needed to define and conduct research. This research will develop and apply a model for conceptualizing the relationships between critical thinking skills, other cognitive variables, and performance.

PHASE I: Military and academic literature will be reviewed to identify a comprehensive list of critical thinking skills, attitudes, other cognitive variables, procedural knowledge, tasks, and performance measures relevant to military decision making. A framework will be developed which models the relationships between critical thinking skills, levels of generality of thinking skills, attitudes, knowledge, subtasks, tasks, and task performance within military decision making processes. Based on interviews with subject matter experts, two or three important critical thinking skills will be selected for further investigation and an explanation for their selection provided. These skills will be ones judged to be trainable and to significantly impact military decision making performance.

PHASE II: Work in Phase II will apply the model developed in Phase I to: (1) develop and evaluate procedures to train the selected critical thinking skills, and (2) conduct research to address questions such as the following: What are the predictors of critical thinking performance? Are the selected critical thinking skills trainable? How should they be trained? How should the critical thinking skills be measured? How much training is needed to effect a significant improvement in the skill? Does improvement in the selected critical thinking skills significantly improve performance on military decision making processes?

PHASE III DUAL USE APPLICATIONS A major commercial market for the products of this SBIR lies in the training programs of large, mid-size and small business and corporations. Corporations have an interest in improving the thinking and decision making skills of their managers and high level decision makers. The procedures developed in this SBIR to train and measure critical thinking skills could be packaged for on-going in-house training programs, vendor training seminars, high-level retreats, and CDs for self study. Another market is the general public. Americans have a well developed interest in self improvement. A video for improving thinking skills for professional advancement could be developed and marketed as self-improvement training

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KEYWORDS: critical thinking skills, cognitive skills, military decision making process, training

## U.S. Army Research Laboratory (ARL)

A99-012

TITLE: Lightweight Personal Protective Head Gear Communication System for the Dismounted Soldier

TECHNOLOGY AREAS: Human Systems, Materials/Processes

OBJECTIVE: Design and develop a lightweight personal helmet and face shield protective system which does not interfere in detecting auditory signals or localization ability and provides personnel protection for the individual soldier.

DESCRIPTION: The future combat helmet for the dismounted soldier is expected to have multiple capabilities to include visual displays and auditory communication features as well as providing the traditional fragmentation ballistic protection and a possible ballistic enhancement to defeat small arms threats. The purpose of previous helmet designs was limited only to provide personal protection. In recent years, the helmet has undergone an evolution providing not only protection, but also serving as the basis for a personal communication system. The military helmet is often regarded as platform to attach new technology thus increasing weight and changing its purpose. Helmets are beginning to serve as a platform for advanced sensory information communication for the soldier. But current helmet designs and materials, which were not envisioned to support this expanding role for the helmet have not proven to be the ideal candidate platform to reach the AAN goals for the individual soldier. The current PASGT helmet is the standard infantry helmet and was type classified in the late 1970s and fielded in the early 1980s and provides ballistic protection from fragmenting munitions to the head, temple, ear and neck areas and does not provide face protection. During recent experiments with current protective headgear it was revealed that human auditory performance, situational awareness, and speech communication are degraded while wearing the PASGT helmet and future Land Warrior Integrated Helmet Assembly System (IHAS). Additionally, the weight and shape of the helmet limits head movement and exacerbates neck strain while conducting various soldier tasks. Therefore, the challenge of integrating information technology with head and face protection has become significant, making the need to truly begin an effort that covers several areas to include materials science, ballistics, audio signal processing, and human factors engineering. Issues such as lightweight head and face protective materials for ballistic and non-ballistic impact protection, human hearing protection designs, materials and helmet suspension solutions to reduce audio attenuation in the helmet, and sight protection against laser, flash, ballistic/non-ballistic and environmental threats must be addressed. This challenge is a high priority need for both military and commercial users who require a lightweight, ergonomic protective helmet that provides sufficient situational awareness and ballistic and non-ballistic protection. Therefore, the objective of a new reengineered headgear design should provide the requisite ballistic protection without degrading auditory cues critical for the user to maintain situational awareness of the surrounding combat environment. Reengineered design technology capabilities could include active noise cancellation microphones, switching circuitry, digital signal processing, and low detectability of wireless transmissions (i.e., < 50'). This investigation will include the analysis of specific users needs to optimize areas of ballistic coverage based on specifications for threat, weight and conflict scenario. A total redesign of the current helmet and face protective system is envisioned. Additionally, the developed helmet should interface with existing military communication systems and allow open architecture interface capability with future military communication or signal systems. The system should incorporate a speech communication subsystem facilitating binaural radio communication and maintain or enhance (if possible) the ballistic level of the current Personnel Armor System for Ground Troops (PASGT) helmet without an added weight penalty. The effort will address the expanding demands that are being placed on current military helmet designs to meet Army After Next (AAN) individual soldier protective head gear and interface requirements. Current problem areas such as reduced weight, ballistic, eye and face protection, signature reduction and audio signal processing should all be addressed.

PHASE I: Create an innovative advanced personal protective headgear system incorporating a binaural communication interface. Deliver a working prototype demonstrating key capabilities of; (1) lightweight < 4-5 pounds, (2) prototype face shield, (3) acceptable human-helmet communication interface, (4) Eighty percent (80%) speech intelligibility in high noise (> 85-115 dBA) using the helmet system microphone and transducers, (5) undisrupted localization ability to a complex signal compared to the bare-head condition (6) undisrupted auditory detection performance compared to the bare-head condition (7) connectivity with a single COTS radio, (8) integrated head support suspension system for field evaluation. In addition, the contractor must explore and define head and face protective materials for ballistic and non-ballistic impact protection, hearing protection design, materials solutions to reduce audio attenuation in the helmet, and sight protection against laser, flash, ballistic/non-ballistic and environmental threats. This effort must also account for future proposed interfaces between head sub-system components and other such items of equipment to make interfaces as seamless as possible. It is possible that some of the ballistic material end items, such as the face shield and helmet could be Government Furnished Equipment (GFE) if determined by the Government, based on current Army break through technologies in the area. If GFE is furnished, the contractor will be required to modify the GFE as necessary to meet the stated objectives.

PHASE II: Provide a prototype helmet system design that meets the required threat protection levels and area of coverage defined in Phase I. The ballistic protection level of the system must be validated through the use of U.S. defined standards for ballistic performance. This prototype must integrate all the associated suspension and sub-systems for field evaluation and optimize the innovative helmet design and communication interface. The improved working prototype must demonstrate optimized capabilities of the enhanced human-helmet communication transducer interface, and have ninety-two percent (92%) speech intelligibility in extreme noise (115-140 dBA) and (2) plug & play connectivity with various Military and COTS radios.

PHASE III DUAL USE APPLICATIONS: Head and face protection is of prime importance in a number of sports and law-enforcement situations. Enhancing sensory capabilities in a helmet mounted system has numerous commercial applications in the entertainment and game industry and industrial applications associated with advanced human-computer interfaces. Other commercial applications of this technology are likely in fire fighting, disaster relief, chemical, or any high-stress environment in which users must monitor environmental surroundings to maintain situational awareness.

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KEYWORDS: Protective headgear, ballistic protection, face and eye protection, transparent armor, audio displays

A99-013

TITLE: Human Communicative Performance in High Noise Environments

TECHNOLOGY AREAS: Human Systems

**OBJECTIVE:** Design and build a hands-free bone conduction transmitter & receiver transducer incorporating wireless connectivity to existing individual portable military or commercial radio systems for use in high noise (115-140 dbA ) environments.

**DESCRIPTION:** Recent experiments with current technology solutions (Air and skull Bone conduction technologies) show that human task performance is severely degraded when executed within high noise environments that rely upon effective two-way communication. A high priority military and commercial need exists for a light weight, user-mounted, hands-free advanced bone conducted communication transmission and receipt with minimum short-distance sound detectability, and maximum speech intelligibility when operated in high noise environments. Currently available air conduction and skull contact bone conduction technology does not allow hands-free communication in extreme noise (double hearing protection) conditions routinely found in combat or civilian adverse environments. Thus, users must communicate via hand and arm signals or attempt to use radio hand sets which seriously hindering human task performance during combat or civilian rescue operations. The objective system should be designed to be compatible with personal protective headgear, and be user friendly. The "plug and play" interface between the advanced bone conduction transmitter and receiver and various personal radio systems must be wireless and highly reliable to maximize user acceptance when operating in these extreme life threatening environments. Additional technology capabilities would include voice activation, active noise cancellation, digital signal processing, and low detectability of wireless transmissions (i.e., < 50').

**PHASE I:** Create an innovative advanced bone conduction-based wireless communication interface. Deliver a working prototype demonstrating key capabilities of (1) acceptable human-transducer interface, (2) Eighty percent (80%) speech intelligibility in high noise (> 85-115 dBA), (3) wireless transducer-to-radio transmission, (4) connectivity with a single COTS radio.

**PHASE II:** Optimize the innovative bone conduction-based wireless communication interface. Deliver an improved working prototype demonstrating optimized capabilities of (1) enhanced human-transducer interface, (2) ninety-two percent (92%) speech intelligibility in extreme noise (115-140 dBA), (3) energy efficient wireless transducer-to-radio transmission, (4) plug & play connectivity with various Military and COTS radios.

**PHASE III DUAL USE APPLICATIONS:** Commercial applications of this technology are likely in aviation, entertainment, health-care, sports, fire fighting, law enforcement, and disaster relief, chemical, nuclear and biological operations, or any high-stress high-noise environment.

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**KEYWORDS:** Bone conduction communications, wireless communication, human system interface, noise

A99-014      **TITLE:** Multi-modal Speech Recognition

**TECHNOLOGY AREAS:** Human Systems

**OBJECTIVE:** Identify alternative speech input devices which have demonstrated in initial research experiments to contribute to speech recognition accuracy when applied to Hidden Markov Model (HMM) based speech systems such as Entropic's HTK research suite. Develop and implement a fusion algorithm to support multiple input streams into the HMM model. These inputs may be voice data or vector data from alternative input devices such as lip readers or data from other articulators such as vocal folds or the tongue. Develop a methodology for evaluating these devices alone or in multiple combinations to determine the viability of multi-modal suites of these devices. The methodology will evaluate Speech Recognition (SR) accuracy and measure the latency produced by fusing multiple input streams. The fusion algorithm(s) will be evaluated to determine the best fusion method based on the particular suite of input devices being tested. The methodology must have the ability to be implemented on one of the generally accepted speech research tools such as (but not limited to) Entropic.

**DESCRIPTION:** Commercial speech recognition systems have flooded the market. However, these systems are optimized for conventional airborne acoustic microphone input and are not designed for noisy environments or multi-speaker situations. The military must work in high noise with the potential for multi-speaker situations. The use of physiological sensors, conduction

microphones, and other devices offer alternatives to the conventional microphone that may provide significant improvement to SR accuracy when used in harsh environments. The problem with alternative input devices is that the data generated by these devices are significantly different in nature to the input delivered from conventional microphones. The filtering requirements and spectrographic nature of these alternative devices must be accounted for by a highly flexible and adaptive speech recognition system and evaluation methodology. When multiple input devices are used, the data streams must be fused in some manner into the HMM model. We seek innovative solutions to this problem. The fusion may occur as a decision based process prior to accession into the HMM model (thus establishing weights for the model) or the data streams may be combined through a to be designed signal processing algorithm. The system must allow for training the HMM model with alternative data and allow for adaptive filtering and anti-aliasing based on the unique requirements for that particular input device or suite of devices. The end result is a system that may evaluate a wide range of potential devices for SR for use in stand-alone or multi-modal SR systems.

PHASE I: A six to twelve month effort should produce deliverables similar to the following: 1. A market survey of commercial and academic alternative SR input devices (only devices that exist as at least functional prototypes should be considered). 2. The procurement of selected input devices for further evaluation. 3. The design of an SR system capable of accepting multiple inputs (at least two channels) with full DSP capability - while specific hardware selections will be based on performance and cost issues, closely matching the government's configuration should result in cost and schedule savings. 4. The development of an evaluation protocol that measures both SR accuracy and computational latency in quiet and harsh environments. 5. Development of one or more fusion algorithms to support multiple input streams into the HMM-based SR system designed under requirement 3. 6. A prototype paper design of the above system.

PHASE II: A two year effort to complete the following requirements: Year One: Implement a stable and functional SR system as designed during Phase-I and perform evaluations on additional devices identified during the market survey plus additional devices identified and/or furnished by the government. One functional SR system (hardware and software) will be delivered to the Army Research Lab as a requirement of this effort. When fully operational, a series of evaluations will be conducted to determine the best input device and fusion algorithm combination for studies to be conducted in the second year. Year Two: Conduct a proof-of-principle demonstration of the "best-of-breed" input suite and fusion algorithm at one of the TRADOC Battle Labs. This demonstration will require delivery, setup, and integration of the SR system and input devices into the Battle Lab's military information system. The scenario for the demonstration will be jointly designed by the SBIR contractor, ARL, and Battle Lab representatives.

PHASE III DUAL USE APPLICATIONS: The use of noise robust SR technology has wide application in the commercial world. From controlling systems in automobiles or other transportation modes to command of industrial operations in factory environments, the ability to utilize new noise robust input devices flexibly will enhance private industry's ability to reliably use SR as a command and control user interface.

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KEYWORDS: Speech recognition, data fusion, DSP

A99-015      TITLE: Laser Beam Tracking System for Optical Communication Link Between Cross-country Moving Vehicle

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: The recent rapid development of various tools for fast wavefront control [liquid crystal (LC) phase modulators, micro-electro-mechanical systems (MEMS), solid state modulators] has introduced new opportunities for laser beam tracking and control. The objective of this solicitation is to develop a novel fast laser beam tracking and control system that can provide a stable laser communication link between two moving vehicles over the range of 1-5 KM. Laser communication techniques can provide highly secure ground-to-ground wireless data links with high data rates using small light-weight systems. However, the existing laser communication systems can operate effectively only between stationary platforms. This significantly limits potential applications of laser communication systems for military and civilian applications when both transmitter and receiver



are located on moving ground platforms (e.g. moving vehicles) at speeds up to 30 mph. In this case, optical communication requires a new type of laser beam automatic tracking system that can maintain real-time focusing and targeting at the moving receiver. The proposed investigation will contribute to the development of laser communication systems that are robust, lightweight, secure, and operate at high data rates for advanced communications and information distribution technologies.

**DESCRIPTION:** The laser-beam tracking system developed under this program should provide a reliable wireless data link between two cross-country moving vehicles (driving at speed up to 30 mph) with data rates of up to 200 Mbps for distances from 1 - 5 KM using small light-weight systems. The laser communications system supplements other radio frequency communications links to provide high bandwidth, burst oriented secure communications for high data rate transfer requirements such as high-resolution imagery. The laser communication system should be eye safe in accordance with ANSI organization standards.

**PHASE I:** Demonstrate feasibility, design and develop a prototype laser-beam tracking system for optical communication data link.

**PHASE II:** Incorporate the developed laser-beam tracking system with a laser communication system. Demonstrate laser communication laser link between two moving vehicles. Develop and demonstrate commercial and military applications, and leverage market opportunities.

**PHASE III DUAL USE APPLICATIONS:** The laser-beam tracking system should allow the future integration of fiber and wireless communication systems into a communication network that includes both stationary and moving/flying platforms. This will result in wireless, small size, low power, high-performance intelligent devices suitable for a number of military applications. **NON-MILITARY:** High-speed free-space communication data transfer between automobiles, helicopters and industrial robots.

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**KEYWORDS:** Laser communication, high speed data transfer, wavefront control

A99-016      **TITLE:** Speech Translation for Mobile Environments

**TECHNOLOGY AREAS:** Human Systems

**OBJECTIVE:** Identify system architectures for speech recognition and translation that can operate between English and multiple other languages on highly portable (e.g., wearable or hand-held) platforms. These architectures should enable robust continuous speech recognition (CSR) and accurate translation between two talkers who do not speak the same language. Software should provide for easy re-targeting to new domains within a language by users who are not experts in the technology. It should also allow new languages to be efficiently trained by software experts, thus enabling rapid extension to the variety of languages encountered in coalition operations, in conflicts, and in peace keeping operations around the globe.

**DESCRIPTION:** The Information Science and Technology Directorate is leading the ARL Digitization and Communications Science thrust. One aspect of the digitization effort is development of methods for providing data for warfare (and operations other than war) to the soldier in a manner that can be readily assimilated and used. On today's battlefield of multi-national coalition forces as well as multi-lingual adversaries, rapid translation of natural speech is essential. Moreover, in operations other than war and in low-intensity conflicts, conversation with indigenous peoples who do not speak English is key to success for a range of missions, including those of special operations, intelligence, and military police, as well as support services (e.g., chaplains). However, currently deployable technology is limited to conversion of fixed spoken phrases and does not support flexible, open dialogue needed for realistic missions. Recent research into speech-to-speech translation, however, shows that support for spontaneous dialogues is feasible in constrained domains (Bub, Wahlter, & Waibel, 1997; Frederking, Rudnick, & Hogan, 1997).

**PHASE I:** A six-month effort should produce deliverables similar to the following: analysis of approaches to major technical challenges (e.g., accurate interpretation of utterances despite recognition errors); identification of sample dialogues typical of coalition and adversarial communications; definition of efficient language models for task-specific dialogues; identification of methods that naturally constrain expression to accommodate SR boundaries; identification or development of methods of natural language processing/understanding (NLP) that are robust to speech recognizer errors and that exploit pre-existing systems for text translation; exploration of limits of platform size to support CSR and NLP; and concept demonstration of a speech translator between a selected language and English. Target languages may be French or Spanish; however, languages of particular interest include Arabic and Korean.

PHASE II: A two-year effort might address aspects similar to the following: development of software suites for recognizing and translating between 3 different language pairs, each of which includes English and one of which must include a critical difficult language (e.g., Arabic or Korean); design of prototype wearable platform with human factored, robust channels for speech input and output; demonstration of authoring interface for extending dialogue domains as well as training new languages; coordination with an ARL testbed to further explore speech translation associated with Army systems; development of approaches to evaluation of speech translation systems (e.g., with regard to utility and quality); and initial interface to Army applications (e.g., selected battlefield visualization system products).

PHASE III DUAL USE APPLICATIONS: This work has enormous potential for improving military C3 and analogous civilian systems. In the civilian sector, beneficiaries could include any industry requiring international communications and conferencing. Specific markets that have employed limited speech conversion software but that call for more flexible and extensible translation software on mobile platforms range from law enforcement, emergency relief, and clinical medicine to tourism.

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KEYWORDS: Speech translation on wearable computer

A99-017

TITLE: Monolithic Integrable Optoelectronic Devices With Variation of the Bandgap and Strain

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: 1. Develop a technique that can vary the energy bandgap and the strain in a semiconductor optoelectronic waveguide structure within the same wafer as grown (preferably without epitaxial regrowth). Therefore, low-cost monolithic integrated photonic circuits, including both polarization specific active and passive devices, can be made from this wafer.

DESCRIPTION: Currently various optoelectronic (OE) devices (lasers, amplifiers, modulators, splitters, etc) are made from different materials and are integrated into OE circuits/systems. This results in the high cost of fabrication due to the device coupling/integration, regrowth, and packaging. This high cost may prevent the manufacture of large highly integrated OE/photonic systems that can be used to implement new technologies such as photonic phased array antenna and RF photonic signal processing. A monolithic integration technique is critically needed. For monolithic integration, only semiconductor material can be used to make all the types of devices-- from laser to passive waveguides. However, a photonic integrated system may require different devices (active and passive) that have different energy bandgaps. Therefore, the technical goal for the proposed research is to develop an inexpensive method for monolithic integration in which one can vary the bandgap within the same semiconductor wafer. For example, this can be done by selective epitaxial growth on wafers patterned with SiO<sub>2</sub> parallel strip masks with an opening gap. By varying the width of the strip or the gap between the strip, the bandgap of a quantum well (QW) waveguide material grown between the strips can be shifted. This technique also allows one to control the strain of the QW, which can be used to control the polarization properties of the material.<sup>1,2</sup> Other methods can also be used. However, any method has to meet the following requirements: (1) be capable of 0 to 100 meV bandgap variation, (2) this bandgap variation as well as a strain variation must be artificially controllable in the designate areas with high-quality uniform local material that can be used to fabricate the waveguide devices, and (3) regrowth should be avoided to generate the active layer of the devices.

PHASE I: Design the epitaxial growth/fabrication technique with a regular optical waveguide p-i-n device structure that can be used for both the laser/amplifier and the modulator. Calibrate the growth for each epilayer in the device structure. Grow the device structure, meet the standard specifications in characterizations, and demonstrate the bandgap shift.

PHASE II: Study the effect of the growth condition change (temperature, pressure, etc) on the selective growth rate or composition (bandgap) change rate, and identify the control parameters for the rate change. Calibrate the bandgap variation rate and strain variation with the control parameters. Grow a monolithic integrated waveguide subsystem including at least three types of device materials such as a 1 x 2 splitter, Mach-Zehnder modulator, and amplifier. The amplifier material bandgap should be near 0.8 eV (or 1.55  $\mu\text{m}$ ), the modulator's bandgap should be about 0.85 eV, and the passive waveguide's bandgap should be about 0.9 eV. Prototype materials need to be delivered to ARL.

PHASE III: DUAL USE COMMERCIALIZATION: A low-cost monolithic integration technique in optoelectronic materials is needed for many photonic integrated circuits in military and commercial applications such as communications (fiber telecommunication, WDM, optical control of phased-array antenna, RF photonic link, fiber-radio), sensors, guided missile and missile defense (microwave-photonic radar system, optical gyroscope), and information networks (optical signal processing/computing).

COST REDUCTION: Nearly 90 % of the cost for integrated OE systems comes from the integration (testing of individual devices, device-to-device/fiber coupling/interconnect, packaging, etc). This technology is aimed to eliminate this cost!

KEYWORDS: Optoelectronics, monolithic integration, selective area growth, semiconductor, waveguide device.

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A99-018

TITLE: Hyper-spectral Terrain Understanding for an Unmanned Ground Vehicle (UGV)

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: To develop terrain understanding technology suitable for implementation on a military UGV. Essential components of terrain understanding include the ability to recognize the presence of and classify terrain elements such as the following from sensors on-board the vehicle, at ranges of 50 meters or more (depending on the nature of the feature). Natural features: trees, bushes, grassy areas, areas of marsh grasses, wooded areas, surface water, mud, rocks, stumps, animals. Man-made features: roads, vehicles, buildings, bridges, people.

DESCRIPTION: Current Army After Next (AAN) doctrine projects the use of unmanned ground vehicles (UGV) for a variety of tactical roles: from scout to weapon carrier to mine detector. These vehicles will be capable of autonomous, tactical navigation across terrain mapped only at low resolution, day or night, and in adverse weather. A key enabling technology enabling such performance is the ability of the UGV to create a real-time understanding of its environment. An iconic representation is required over and above the current geometric understanding utilized for obstacle detection and avoidance. One possible solution is the coupling of hyper-spectral imagery with advanced perception algorithms. The analysis of hyper-spectral imagery from satellites is in common use for terrain understanding, and hyper-spectral techniques have been applied to terrestrial problems such as target acquisition and mine detection. There is no record, however, of hyper-spectral terrain understanding techniques having been applied to imagery from a land vehicle in real time. The hyper-spectral signature of terrain elements, fused with related phenomenology, has potential to enable a UGV to understand its environment sufficient to perform the military behaviors essential to its survival on the AAN battlefield. TASK

Develop comprehensive list of terrain elements that must be correctly identified in order to achieve specified military behaviors. Identify phenomenology enabling essential components of terrain understanding for the UGV application. Identify (or modify existing) sensors suitable for sensing these phenomena, with range, field of view, and physical characteristics consistent with the constraints and operating environment of a small UGV traveling cross-country at 30 mph. Establish an architecture for recognizing the presence of classifiable elements in the operating environment, and for classifying them. Develop algorithms which robustly recognize and classify terrain elements. Develop terrain understanding package consisting of sensors, algorithms, software, and processing hardware, using technologies suitable for integration with a UGV. Demonstrate and validate proposed approach in field tests.

PHASE I: Develop comprehensive list of terrain elements that must be correctly identified in order to achieve specified military behaviors. Identify phenomenology enabling essential components of terrain understanding for the UGV application. Identify a representative subset of the terrain elements for initial proof of feasibility (POF), draft test plan, and submit to sponsor for approval. Identify sensors required for POF test and obtain test data. Develop and demonstrate pilot classifier that will demonstrate the feasibility of the chosen approach.

PHASE II: Identify larger and more significant subset of the terrain elements for phase 2 effort. Establish an architecture for recognizing the presence of classifiable elements in the operating environment, and for classifying them. Develop algorithms that robustly recognize and classify terrain elements. Develop prototype terrain understanding package using technologies suitable for integration with a UGV. Demonstrate proposed approach in field tests.

PHASE III DUAL USE APPLICATIONS: Detection and classification of man-made objects are of potential value to commercial vehicle programs for on-road obstacle detection and avoidance. Current DOT programs focus on detection, but not classification. Detection and classification of natural objects may be of use in Agriculture, Forestry, and Construction. Agriculture in particular is on the verge of fielding unmanned equipment, however automated differentiation between healthy and unhealthy crops "on the fly" could benefit manned agricultural vehicles as well.

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2. "Overview of the Demo III UGV Program", by Charles M. Shoemaker and Jonathan A. Bornstein, Proceedings of SPIE Unmanned Ground Vehicle Technology I, 13-15 April 1998, presents a view of the operating environment and characteristics of a military UGV.

KEYWORDS: Hyper-spectral, Object Classification, Terrain Classification, Unmanned Ground Vehicle, Robotics

A99-019 TITLE: Oil-free Auxiliary Power Unit and Propulsion System Technology

TECHNOLOGY AREAS: Air Platforms, Ground and Sea Vehicles

OBJECTIVE: Develop innovative oil-free compliant foil bearing and seal systems in a size class suitable for application in auxiliary power unit and gas turbine engine turbomachinery systems used in Army vehicles.

DESCRIPTION: This topic seeks innovative oil-free compliant foil bearing and seal technology suitable for use in the development of oil-free auxiliary power units and gas turbine engines for Army vehicle systems. The proposed research must push oil-free turbomachinery rotor support system technology beyond the current state-of-the-art level into larger sizes and high-temperature environment applications relevant to military vehicle systems. The proposal must address anticipated benefits of the technology (such as efficiency, cost, power density, reliability, maintainability) to the vehicle system through complete

elimination of the oil lubrication system. The proposal must identify the critical technology barriers that the proposed research effort must overcome to succeed in applying and commercializing the technology. The proposal must discuss the innovation and risk involved in overcoming the critical technology barriers and present a reasonable basis, approach, and timeline for success. The proposal must include information on potential spin-off military applications and commercial dual use applications.

PHASE I: Through experimental testing and/or analytical modeling the proposer must show feasibility of the proposed methodologies to overcome the identified critical technology barriers. Prepare a Phase II research plan.

PHASE II: Demonstrate (in a laboratory setting) the technology at an appropriate scale relevant to the target military vehicle system application and in a relevant operating environment (speeds, loads, temperatures, pressures).

PHASE III DUAL USE APPLICATIONS: This technology is applicable to virtually all military and commercial aircraft/helicopter gas turbine engines, ground vehicle auxiliary power units, and stationary gas turbine power generators.

KEYWORDS: Foil bearings

A99-020      TITLE: Innovative Processing of Multifunctioning Composite Armor for Ground Vehicles

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop novel methods to process multifunctional polymer matrix composite (PMC) materials to be used in ground vehicle applications requiring multiple performance criteria such as ballistic, blast, electromagnetic and fire protection and providing potential for improvements in cost, weight, damage tolerance, and repairability. Utilize emerging technologies which may include but are not limited to density-graded ceramics, controllable fiber-matrix interphase gradients, dissimilar material adhesion through diffuse interfaces, through-thickness reinforcement, alternative reinforcements, and co-cure-enabling technologies such as co-injection resin transfer molding, electron beam curing, and induction bonding.

DESCRIPTION: The Army has a critical need for new multifunctional material solutions for armored combat systems such as armored personnel carriers, self-propelled howitzers, up-armored wheeled vehicles, and tanks. Revolutionary approaches are required to significantly (up to 50%) reduce the mass of these systems and improve their mobility and transportability without sacrificing survivability or maintainability. Current concepts have been developed that begin to meet the multifunctional and reduced weight requirements necessary for the next generation of combat ground vehicles, but these concepts must be improved to realize the full benefit of lightweight multifunctional materials. Recent advances in composite materials science and the development of new processing techniques have not been fully exploited in the production of multifunctional composites for these applications. Furthermore, tailored and/or graded interphases between dissimilar materials have been shown to influence the performance of composite armor, but this approach has not yet been optimized. Hence, there exists a need to devise methods and materials that apply recent technological innovations and scientific understanding to achieve real weight reductions and increased protection from multiple threats. Complex material interactions between PMCs and other materials in multifunctional materials can be tailored to provide an optimized balance of functionality for combined structural, ballistic, electromagnetic, fire, cost, weight, and supportability requirements.

PHASE I: Identify the most promising multifunctional material and materials processing technology for ground-based vehicle applications. Demonstrate feasibility of processing technology by fabricating and evaluating flat test panels of the composite material. Achieving significant improvements in critical parameters such as ratio of areal density-to-level of ballistic protection, fire-protection levels, cost-saving potential, shock wave transmission/reflection mitigation, energy absorption levels, improved damage tolerance (higher ratio of average through-thickness delamination to square of max delamination) will be a factor in determining the success of Phase I. The new technology should represent significant progress toward revolutionary improvements in vehicular armor such as ballistic protection, fire protection, signature reduction, manufacturing costs, and/or damage tolerance.

PHASE II: Design an armor material system incorporating the new material and/or processing technology identified in Phase I. Fabricate full-scale samples of this concept armor for ballistic, fire, damage tolerance and/or EM testing and apply appropriate cost models to demonstrate significant improvements in operational savings and cost reduction using the new material and/or process. Prepare prototype armor materials for field testing in conjunction with TACOM and the Army Research Laboratory. Phase II should also demonstrate the benefits of the material and/or process for large-scale commercial applications and provide a technical data package.

PHASE III DUAL USE APPLICATIONS: There are expected to be a large number of near-term and future Defense and commercial applications of multifunctional composite materials. In addition to a wide range of ground combat vehicles, defense applications include amphibious assault vehicles, aircraft and shelters. Law enforcement and armored security vehicles, fire fighting vehicles, anti-terrorist infrastructure, blast-resistant cargo containers, and damage resistant ship hulls are all potential beneficiaries of the improved multifunctional materials.

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KEYWORDS: armor, composite materials, ballistic protection, fire-resistant, signature reduction, polymers, ceramics, materials processing and manufacturing technology

#### U.S Army Research Office (ARO)

A99-021 TITLE: Production of High Energy-absorbing Metallic Foam Structural Components

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To determine the potential of metallic foams to enhance the energy absorbing characteristics of lightweight structural components subjected to dynamic loading and to develop design guidelines and procedures for optimizing their performance.

DESCRIPTION: Structural metallic foams have high specific stiffness and provide excellent energy absorption characteristics at significantly higher strength levels than polymer foams. In addition, they can be used over wider ranges of temperature, are non flammable and can be further processed using numerous secondary operations. Encapsulation of metallic foams in hollow shapes eg. tubes, channels, etc., should lead to the production of structural components that retain their light weight but have improved specific stiffness and greatly enhanced energy absorbing characteristics under conditions where the rate of loading is very high (dynamic). What is required is: (1) the development of the understanding of the synthesis and processing technology involved in the fabrication of foam filled structures; (2) the development of the understanding of the influence of foam morphology on the dynamic mechanical properties of the structures; and, (3) development of the methodology for optimizing the properties that give structures with superior energy absorption characteristics.

PHASE I: Demonstrate the proof of concept for the fabrication of a representative component and optimization of its dynamic mechanical properties to give superior energy absorption in sufficient detail to evaluate the potential for the production of a complex component for a DOD or commercial application. Critical processing steps should be identified and preliminary materials characterization and testing of the component should be performed. A preliminary cost/economic analysis should be performed and a partner identified for commercial scale-up and application.

PHASE II: The structural members envisioned could be integrated into aircraft, rotorcraft, road/rail vehicles and other transportation systems to improve crash worthiness. They could also be an integral part of an armor system to defeat blast or projectile threats. Focus on the fabrication of a full scale component which can be tested in either a current or advanced system. Conduct additional materials characterization and dynamic testing as required. Document expected weight savings, cost savings and/or new capabilities.

PHASE III DUAL USE APPLICATIONS: On Defense-- Lightens the force for enhanced mobility, maneuverability and deployability (airliftable) through decreased overall structural weight. On Commercial-- Provide lighter weight more fuel efficient transportation systems. Overall, provide improved survivability in those scenarios where personnel are subjected to the effects of dynamic loading(crash/blast/projectile threats).

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KEYWORDS: Metallic foams, fabrication, dynamic loading, energy absorption, light weight structures

A99-022 TITLE: Tunable Materials for Integrated Adaptive Electronics

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment, Materials/Processes

OBJECTIVE: Develop field-tunable, low-loss thin-film ferroelectric materials for integrated adaptive electronics.

DESCRIPTION: Frequency agility and directional broadcasting are important attributes that the military would like to incorporate into future generations of wireless communications and radar tracking systems. This topic seeks to investigate and develop new, low-loss, thin-film ferroelectric materials with tunable field-dependent properties, e.g. electrical permittivity or magnetic permeability, which will operate above 10 GHz and be appropriate for integration into future generations of adaptive, frequency-agile RF electronics. Specific capabilities being sought include frequency tunable filters and oscillators, and phase shifting elements for directional phased-array antennas. Innovative materials and processing concepts that provide significant performance and cost advantages over current state-of-the-art materials are being sought. The ideal materials should provide tunability over an octave of frequency range (10-20 GHz), afford at least 2-pi of tunable phase range, require relatively low fields for tuning, and have loss tangents below 0.001. Proposals should emphasize the development of new material systems and possibly also propose novel integrated device structures that exploit the specific attributes of the material under development. Possible approaches might include: 1) ferroelectric films with high field-dependent electric permittivities, 2) composite ferroelectric-ferrite films with tunable electric permittivity and magnetic permeability, 3) new material concepts which afford high electrical tunability, and 4) novel device schemes that circumvent critical shortcomings of existing materials.

PHASE I: Investigate and demonstrate the feasibility of an innovative approach to the development of a tunable thin-film materials that will significantly improve communications and radar system performance, and reduce costs in relation to present state-of-the-art materials and approaches. A detailed study of the proposed material / device characteristics should be completed as part of this task.

PHASE II: Implement the innovation, which should include the design and testing of a prototype system. Explore major cost and reliability issues associated with the innovation in the context of commercial viability.

PHASE III DUAL USE APPLICATIONS: Frequency agility and directional broadcasting (via conformal antennas) are important attributes that the military would like to incorporate into its next generation of low-power, broad-band wireless communications and radar tracking systems. This research is in direct support of the Army initiative to digitize the battlefield and develop smart weaponry. At the same time, dual use opportunities exist, since these same materials can be adapted for commercial wireless communications and obstacle avoidance systems. The program is intended to introduce breakthrough technologies (new capabilities, enhanced performance, and reduced system size and weight) that significantly enhance future system performance and reduce costs.

KEY WORDS: Frequency-agile RF electronics, wireless communications, adaptive electronics, phased-array antennas, low-loss tunable materials, frequency tunable filters and oscillators, phase shifters, ferroelectrics, and ferrites

A99-023                      TITLE: Full Field Spray Diagnostics

TECHNOLOGY AREAS: Air Platforms, Ground and Sea Vehicles

OBJECTIVE: Develop a particle sizing technique capable of instantaneously sizing all droplets in a liquid spray.

DESCRIPTION: Liquid sprays are encountered in a number of systems of Army interest. The principal focus here is on fuel sprays in diesel and gas turbine engines. Currently there is no accurate technique for the rapid determination of the particle size distribution in such sprays. Full-field techniques, the "Malvern-type" systems, measure moments of the spray, typically the Sauter-mean diameter. The most widely used, and accurate, system for droplet measurement is the phase-doppler particle size analyzer (PDPA). However, it is only able to probe a small region of the liquid spray at any given instant. What is needed is a technique with the accuracy of the PDPA and the capability to interrogate instantaneously the entire spray. That technique should be capable of determining the droplet size statistics without any a-priori assumption about the shape of the particle size distribution. Consideration should be given to performance in both optically thin and optically dense regions of sprays.

PHASE I: Analytically determine the performance of the proposed system for ranges of spray parameters typically encountered in diesel and gas turbine sprays. Analytically determine the accuracy of the technique and potential sources of error. Conduct experiments to verify the performance of the basic concept using controlled droplet sources. Design a brass-board system, controller and associated data reduction software.

PHASE II: Construct a brass-board system, controller, and software and demonstrate its performance using well-characterized droplet streams, diesel and gas turbine fuel injector sprays, with liquids including JP-8. Determine the accuracy of the system and develop data reduction software to provide both droplet statistics (size distribution, surface and volume weighted means) and probable errors.

PHASE III DUAL USE APPLICATIONS: Defense-Enables development of higher performance, lower fuel consumption engines. Commercial-It is anticipated that the resulting measurement system may find wide applicability in commercial engine development programs. It should also be applicable to other areas where fast, accurate measurement of spray properties is desired.

KEY WORDS: Sprays, diagnostics, diesel and gas turbine engines



A99-024

TITLE: Novel Short Wavelength Light Source System for Portable Sensor Application

TECHNOLOGY AREAS: Chemical/Biological Defense and Nuclear

OBJECTIVE: Development of a short wavelength (400 - 200 nm) light source system for portable sensor applications such as Chemical/Biological detection of warfare agents and/or environmental pollutants by photon-interaction techniques.

DESCRIPTION: Present-day methods of chemical/biological warfare agent detection often rely upon some type of photon-molecule interaction method such as fluorescence. This interaction is most sensitive if there is a single-photon source that is available for warfare agent detection. However, almost all applications of photon-molecule sensor processes in this wavelength range have used resonant multi-photon interactions (either fluorescence or ionization) requiring large lab-based photon sources that are not portable. Due to recent advances in solid state technology it is now possible to create several new types of short wavelength lasers or other light sources that should be much more portable and reliable than current commercial sources in this wavelength range. Examples include (i) solid state Gallium-Aluminum Nitride based heterostructure quantum-well lasers or light emitting diode arrays; (ii) small scale diode pumped Ti-sapphire laser sources that are frequency doubled or tripled by new efficient intra-cavity crystal devices; or (iii) conventional compact arc source powered by high efficiency portable power supply. The total portable system should include light source, UV optics and detection schemes for chemical/biological agent detection and identification.

PHASE I: Demonstrate the operation of a short wavelength (200 - 400 nm) light source agent detection system with an average optical power level of 1-2 milliwatts including UV optics and detection schemes for lab-based simulants of chemical/biological agent detection and identification.

PHASE II: Optimize the performance (e. g. 10-20 mW power level) of the short wavelength agent detection system by increasing both the detection efficiency and portability to achieve field-based military applications for chemical/biological sensors and/or humanitarian mine detection.

PHASE III DUAL USE COMMERCIALIZATION: Much of the commercial market place for this detection system will be driven by environmental chemical agent detection systems that are based on the same physical principles as chemical/biological warfare agent detection. In addition, advanced optical storage applications requiring shorter wavelengths may utilize affordable laser technologies based on the sensor technology described above. Thus low cost new laser sources for sensor applications are a realistic outgrowth of this sensor project. Such portable sensor systems should prove useful in environmental monitoring applications and in the food industry for advanced gas sensor detection of defects in fruits and vegetables. Several large industrial labs have already expressed strong interest in these types of commercial applications.

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KEY WORDS: Short-wavelength light source, chemical sensor, biological sensor, photon-molecule interactions.

A99-025

TITLE: Application of Recent Algorithm Research to ATRs in Cluttered Environments

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop a computer program that will apply recent research on algorithms to recognize the presence or absence of an object in a scene where the object might be partially occluded and may be presented in various poses, where the light shining on the object may be of varying intensity and the image of the scene may be distorted by clutter (noise) introduced either by the sensors producing the image of the scene or by noise present in the scene itself. Although real time processing of an image as it is detected by sensors is desirable and is a long-term goal, the objective here is to process the image after it has been captured and stored in the computer.

DESCRIPTION: Machine vision has long captured the imagination of computer scientists, science fiction writers as well as engineers working on real-world problems. It has, however, continued to be an elusive goal. While optical character recognition programs have been developed that achieve better than 95% accuracy at the word level and machine vision systems are routinely used to inspect products during manufacturing or to enable missiles to lock onto their targets, these systems either operate in tightly constrained situations or offer performance that would be unacceptable if it were not for cost, space or other environmental conditions. Past and current systems fail not only because we lack the hardware that can replicate the human eye

and brain, but also because we do not fully understand how a human processes images and we do not have alternative algorithms to use with the available hardware. In this topic, we seek the development of new ATR algorithms. The needs of some applications can be met with brute force approaches that compare an unknown object's image to that of an image stored in a database and then compute an error function. However, to come close to the performance of humans, there appears to be a consensus that the process involves finding the unknown object's edges or contours followed by additional processing. The contour estimation process is likely to involve "perceptual organization," which requires aggregation of contour primitives using a universal (object-independent) visual grammar. Similar to English grammar, which provides rules to aggregate characters into increasingly complex structures, the visual grammar specifies rules to aggregate contour fragments into a hierarchy of increasingly complex contour representations. These rules, which favor aggregations with certain global properties, such as co-linearity, closure, and symmetry are based on the statistical observation that these global properties are more likely to occur if the contour fragments in the aggregate belong to the same object and are used to compute hypotheses and a probability estimate for each hypothesis. To control computational complexity, those hypotheses with low probability are then pruned. Clearly, object dependent rules need to be added to this universal visual grammar in order to create a specific recognition system. The richness and variability of objects in visual scenes are captured by appropriate deformations of object models in an object database. As in language, if subsequent processing affects earlier probability estimates, then the algorithm should return to the earlier step.

PHASE I: Develop a computer program that finds edges in a scene and uses this information to demonstrate the use of a new ATR algorithm to recognize an object such as a tank from aerial photographs (the object database contains only one element) where the target may be partially occluded and the photograph may contain clutter. The technique should be demonstrated at both visible and infrared wavelengths.

PHASE II: Develop a new ATR algorithm (MS Windows or UNIX environment with GUI wraparound) that recognizes whether any of several objects are present/absent in a scene (the object database contains several elements) where the object may be partially occluded and present in various poses, the lighting on the object may be of varying intensity, and the entire image may be distorted by clutter. Demonstrate the algorithm on a testbed application of your choice.

PHASE III DUAL-USE APPLICATIONS: ATR, optical character recognition, product inspection, analyzing satellite data for mineral exploration, automation of hazardous processes such as those encountered in mining, automation of medical tests such as reading X-rays, sonograms or other images.

KEY WORDS: Image processing, machine vision, software algorithms.

A99-026

TITLE: Digital Image Management Capability: Integrated Computer Interfaces for Image-guided Systems

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: To develop a software-based digital image management capability, using new image processing algorithms that are based on curvature driven flows for non-invasive diagnostic methods in medical imaging and for efficient processing of military imagery for ATR.

DESCRIPTION: Digital image management is based upon the processing, development, interpretation, archiving, transmission and content-based retrieval and screening of very large volumes of image data without the use of film. In the imaging field, newer imaging modalities use a digital format and can be transmitted electronically throughout a building and/or externally to remote facilities. In 1990, a standard interface protocol was established to enable the integration of multi-brand systems, creating the opportunity for extensive interactive networks. Innovative image processing software is a crucial element in providing superior capabilities for performing primary functions in the acquisition, visualization and analysis and presentation of images. A key rate-limiting step in the fast acquisition, interpretation and diagnosis of images is the image processing software, which typically does not make use of the full potential of the speed achieved by existing hardware. In medicine, imaging systems are used as non-invasive methods for diagnosing diseases and injuries. Two key factors contribute to the emerging importance of the digital image management market: (1) the digitalization of all medical imaging modalities has caused exponential growth in the number of images generated by the radiology sector and has created an urgency to solve the problems of image storage space and (2) due to insurance restrictions, a need is emerging for disseminating image information from the patient source to remotely located consulting professionals, without the necessity of an office visit. Hence, the establishment of Picture Archiving and Communications Systems (PACS) and teleradiology facilities are the fastest growing segments of the medical imaging market. In the military, image processing is of great importance with various applications including enhancement of compressed images for multimedia environments, terrain related imagery, semi-autonomous navigation, fire control, C3I, and denoising and segmentation of SAR, ISAR and IR images in ATR. Such efforts will lead to enhanced man-machine interfaces for interactions with computers and more complicated systems such as remote-controlled

weapons and vehicles. In addition, this project is important because of the worldwide deployment of American troops and the necessity to have fast, first rate expertise for the variety of diagnostic tools available to the troops wherever they are stationed.

PHASE I: Develop efficient image processing software code for the digital implementation of curvature based flow methods for image enhancement, compression, and segmentation to demonstrate feasibility of the techniques on SAR, ISAR, and IR images in ATR, and MR, CT, and ultrasound in medical imagery.

PHASE II: Develop a prototype digital image management software package (MS Windows or UNIX environment with GUI wraparound) that concentrates on integration issues. The software tool will process, develop, interpret, archive, transmit and perform content-based retrieval and screening of high volumes of image data. Demonstrate the software on a testbed application of your choice.

PHASE III DUAL USE COMMERCIALIZATION: ATR, HMOs, hospitals, remote medical clinics, health care delivery systems, OEMs in the health care industry.

KEY WORDS: Digital Image Processing, Computer Vision, Control, Man-machine interfaces.

A99-027      TITLE: Engineering Design Software for Military Incinerators

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Software for Incinerator Design using Engineering Process Models

DESCRIPTION: Nerve and mustard agents and many other toxic military materials contain phosphorus, sulfur, and halogens. Until recently, little was known about the combustion chemistry of these materials. Incineration has been shown to transform organic materials into oxides with very high effectiveness; but lack of understanding of the combustion process has forced the over-engineering of units resulting in substantially increased expense. The lack of rational foundation in the design process has also contributed to Army incinerators being under nearly constant legal challenge. This project will produce the first tools for rational engineering design of optimized, economical incinerators for military materials. Using best available data as inputs, the engineering design software will give optimum operating conditions, destruction efficiency as a function of throughput, reactor configuration, product species and concentrations, capital and operating costs, and energy needs. The software will provide information about potential onset of reactor upsets and enable diagnosis of failures. The software must include modules for pyrolysis and gas phase combustion and must include detailed chemical kinetics based on best available reaction mechanisms.

PHASE I: Develop software including all required modules as proof-of-concept

PHASE II: Develop simulator and test against appropriate data set from pilot or full scale plant tests (in literature or new measurements as required). Package simulator must be "user-friendly" for potential DOD and civilian customers.

PHASE III DUAL USE COMMERCIALIZATION: : A wide range of toxic compounds targeted by this program and used by civilians are many pesticides, herbicides, and PCBs. This project will enable rational, optimized design of incinerators for these hazardous materials used in the civilian sector.

KEY WORDS: incineration, combustion, toxic, oxidation, engineering design

A99-028      TITLE: Sensor System for In-situ 3D Soil Stress Analysis

TECHNOLOGY AREAS: Materials/Processes, Ground and Sea Vehicles

OBJECTIVE: To develop a soil stress sensor system for the in-situ measurement of the stress state in three dimensions for application to vehicle-terrain interaction modeling and simulation.

DESCRIPTION: Understanding of vehicle traction element interaction with soil, which is a critical Army need, can be advanced through measuring devices which characterize the in-situ soil stress state. Accurate data of this kind is important both for the definition of constitutive relationships and for physical model development and validation that (a) will lead to an enhancement of the current generation of mobility models, (b) will permit the introduction of dynamic terrain into the synthetic environments used in interactive distributed modeling and simulation, and (c) be utilized in the design and prototype testing of new vehicle systems. The requirement is for a stress sensor system for the in-situ measurement of stresses in three dimensions, with special emphasis on the measurement of lateral forces that develop during steering or turning of a wheel or track. Issues related to coupling of the soil must be addressed. The system should be field portable and designed so that in-situ emplacement can be accomplished with minimal disturbance to the soil. Deployment at various depths, down to a maximum

of one meter, is required. Data collection and storage capabilities for multiple data sets also are required, and instrumentation should interface with personal computers. Calibration, noise reliability, and repeatability related to measurements are issues to be addressed in the development, test, and evaluation of the system with the goal being accurate measurements.

PHASE I. The Phase I work will develop, demonstrate, and deliver to the Army an in-situ soil stress monitoring system. The system will have the capability for accurately measuring in-situ stresses in three dimensions within a soil during an application of a vehicle load. Soil coupling will be investigated. Methods for emplacement of the sensor system to minimize soil disturbance will be explored.

PHASE II. This phase will consist of conducting field tests to validate the in-situ stress measurement system. This testing will evaluate the accuracy, reliability, and repeatability of measurements and the performance of the system for vehicle traffic over sensors arrayed in various configurations in different types of soils, the specifics of which will be defined through consultation with USAE Waterways Experiment Station Geotechnical Laboratory.

PHASE III DUAL USE APPLICATIONS: Design and development of an in-situ soil stress sensor system will benefit the manufacturers of off-road vehicles and heavy construction, agricultural, forestry, and mining vehicles.

KEYWORDS: In-situ Soil Stress Measurement

A99-029

TITLE: 4D Remote Measurement of Tracer Concentrations for Atmospheric Dispersion Studies

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To provide a fieldable, low maintenance system to measure the four dimensional field of mass concentration of gases commonly used in atmospheric dispersion field tests at high space and time resolution in the atmospheric boundary layer.

DESCRIPTION: The Army has a critical interest in the atmospheric dispersion of aerosols and gases (chemical and biological agents) affecting soldiers and civilians. It relies on computer models of the dispersion process to estimate local concentrations and their effects on time scales from seconds to days. Griffiths and Megson (1984) note that the lethal dose of some agents is a result of a few instances of very high concentration on the order of seconds rather than longer term (hourly or daily) mean concentration. Current models have large error bars which lead to fatally faulty analyses and predictions of battlefield hazards. Recent recommendations (ARL, 1998) call for (1) new intensive field studies of fluctuating tracer concentrations in evolving plumes as a beginning step in development of better models, and (2) for high resolution measurements of tracer concentrations in space and time using advanced remote sensing techniques. To accomplish that research, instrumentation is needed that has the capability to measure dilute concentrations of tracer material as a function of position and time away from a known source at spatial resolutions of 50 meters or less and on the order of seconds or less within the atmospheric boundary layer. The system must operate in day or night, with minimal supervision and be transportable to realistic test conditions. As an example, a proposed system might use differential absorption lidar (DIAL) technology for the detection. Proposals to use other innovative, viable, potential technologies are strongly encouraged.

PHASE I: Prepare a proof-of-concept study demonstrating the ability of the proposed approach to measure concentration resulting from a known, single, controlled source of propylene and, secondarily, sulfur hexafluoride, as a function of space and time. (Other potential tracers will be considered with significant justification as meeting current in situ tracer measuring capability.) Figures of merit should include the minimum resolved volume and minimum detectable concentration within that volume at ranges of 100, 500, and 1000 meters from the source; the time required to make those measurements; and the time required to measure the spatial distribution of concentration within a volume from the source to 3000 m downwind by 1000 meters across wind and 300 meters altitude. Such determinations can be expected to depend upon operating capabilities of components of the instrumentation, signal processing, the range of realistic values and assumptions, and the physical principles involved. Assessments of the principal trade-offs in system design should be provided. A reference concentration plume will be provided the selected candidates. Instrumentation design should also consider size, power requirements, and dependability of the system.

PHASE II: A prototype instrument system to make the measurements per the design will be constructed utilizing off-the-shelf equipment insofar as feasible, an approved test plan developed, and field tests conducted in conjunction with Army dispersion experiments.

PHASE III DUAL USE AND COMMERCIALIZATION: The technology developed within this effort is readily adaptable to measure other trace gases within the air. These gases may come from natural or anthropogenic sources. Quantitative measurements of these gases will be possible at the ground level and aloft at time and space scales unattainable using in situ monitors for these gases. Furthermore, the systems are also adaptable to measure the wind components that move the gases. The technology is directly applicable to for stand-off detection of certain toxic or benign trace gases on the battlefield. This capability will invaluablely enhance soldier and civilian protection capability in chemical attack. The

technology should also be compact, relatively lightweight, and man-transportable, permitting numerous sampling strategies and deployments. This should also permit installation of the systems on airborne vehicles for maximum utilization.

REFERENCES: Griffiths, R.F. and L.C. Megson, 1984, Atmos. Envir. 18, 1195-1206 Army Research Laboratory: Proceedings of the Army After Next Tactical Decision Aids Technical Symposium, El Paso, TX, April 14-16, 1998.

KEY WORDS: Chemical/Biological defense, Atmospheric dispersion models, Concentration fluctuations, Remote sensing of tracer material

#### **U.S Army Aviation Research, Development, and Engineering Center (AVRDEC)**

A99-030 TITLE: Innovative Methods for Evaluating and Characterizing Combat Performance using Data from Full Mission Simulation

TECHNOLOGY AREAS: Human Systems, Information Systems Technology

OBJECTIVE: Develop methods and standards for conducting full mission simulation test and evaluation that will provide clear answers to research and development questions, and maximize the risk-reduction benefits of large advanced system simulation.

DESCRIPTION: Classically, simulation studies of soldier performance in combat have gathered and reported traditional data: kills, losses, mission timelines, etc. Seldom have future system benefits been easily and clearly quantified in manned virtual Full Mission Simulation (FMS). Obviously, FMS is a worthwhile cost and risk reduction activity prior to live evaluations of future technology, however success to date in obtaining valid objective data from simulation has been rare. Useful, meaningful human performance data collected during FMS is a valuable source of design feedback, and can often be a reliable indicator of real-world system performance. Phase I of this SBIR would explore available FMS literature/reports/data to examine what test designs, metrics, and analysis approaches have been used with what degrees of success in previous simulation studies. Existing data would be examined to identify relationships among gathered data that support pre-existing hypotheses about human performance in simulation. Phase II would apply the methods developed during Phase I to an actual full mission test and evaluation effort.

PHASE I: Analyze existing FMS methodologies and identify the contributing factors to failures of FMS to produce reliable, significant quantitative data and identify contributing factors to successes in gathering reliable data to support FMS tests of future system effectiveness. Develop and evaluate methods to create metrics that report performance as a function of single factors such as sensor performance and as a function of complex combinations of factors such as line of sight by threat system type over time for different soldier experience levels. Develop candidate T&E methodology guidelines for FMS research to enable future simulations to glean the maximum test and evaluation benefit.

PHASE II: Validate the guidelines and metrics methodology developed during the Phase I effort by applying them to a full mission simulation of a human-machine system in complex combat environment as in a Battle Lab Warfighting experiment. Collect data during simulation, and reduce and analyze it using innovative analytical techniques proposed during Phase I. Propose modifications to the approach based on lessons learned during and after the simulation. Design a system architecture and set of software tools that have applicability across many different FMS environments. Publish a guideline handbook documenting validated methodologies.

PHASE III DUAL USE APPLICATIONS: Tools and techniques that can optimize the use of large-scale system simulation involving humans and advanced technology future systems can applied across a wide range of human-computer system interface environments, including energy control systems, air traffic control, and computer aided design technologies.

REFERENCES: Triggs, T.J. (1996). Some critical human factors issues and challenges in simulation and testing. Proceedings of the First International SimTecT Conference, 25-26 March 1996, Melbourne, Australia. ISBN: 0 646 27402 3

KEYWORDS: full mission simulation, test and evaluation, human performance in combat simulation.

A99-031 TITLE: Predictive and Real-time Visual Assessment System and Tools

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Fabricate and demonstrate predictive and real time Visual Assessment System and Tools (VAST) designed to characterize visual cueing levels for flight and ground crews operating in aided (synthetic) and unaided visual environments.

DESCRIPTION: As the use of Image Intensifiers (I2), Forward Looking Infra Red (FLIR), millimeter-wave radar, low light video and other artificial/synthetic images presented on visual displays are developed for use by crew members in adverse visual environments, the prediction of suitable pilot/operating cueing levels for crew operations has not kept pace. Only predictive technology for the normal human visual spectrum has been provided by weather services, which forecast visibility. In addition real time assessment of the synthetic visual environment are not reliable. Recent advances in sensors, video, meteorology services, display technology, understanding of the human visual system and intelligent systems are now making it possible to provide predictive algorithmic for visual cueing. Gains are being rapidly made in algorithmic advances in pattern analysis, the ability to detect and analyze visual texture, and other cueing technologies essential for the human visual system to efficiently operate within his visual envelope. The VAST would utilize existing technologies to forecast visual cue conditions for crewmembers operating in synthetic visual environments using FLIR, I2, millimeter-wave radar and sensor fusion. In addition the VAST would be able to provide a characterization of the real time visual environment (aided and unaided) to crewmembers. The characterization of the real time visual environment using VAST would also result in a real time methodology for intelligent display control of clutter and for real-time objective determinations of visual cueing conditions for helicopter handling qualities research.

PHASE I: Develop overall system design to include specification of predictive and real-time visual characterization technology. Plans should include possible integration of the real time VAST into a demonstration vehicle and a test plan for the phase II effort.

PHASE II: Develop and demonstrate a prototype VAST in a realistic environment. Conduct testing to prove feasibility over extended operating conditions and several visual environments.

PHASE III: DUAL USE APPLICATIONS: This system can be used by the Federal aviation administration, and numerous other transportation agencies to both predict and measure visual operating conditions.

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15. R. L. Newman, Helmet-Mounted Display flight Symbology Requirements for Military Rotorcraft, Crew Systems TR-98-1 2, May 1998

KEYWORDS: sensors, cueing, vision, visual environments, FLIR, I2, millimeter wave radar, sensor fusion

## TECHNOLOGY AREAS: Information Systems Technology

**OBJECTIVE:** Design of a Simulation Based Acquisition (SBA) Collaborative Environment (CE) for engineering level modeling and simulation to support materiel development and evaluation in a Force XXI mission context. Identify the core components (key models and simulations) of the CE and specify the Engineering and Information System (EIS) environment (key data representations) necessary to support Simulation Based Design (SBD) and SBA of complex Army systems.

**DESCRIPTION:** Simulation Based Design and Acquisition (SBD&A) is rapidly becoming institutionalized as a means of controlling costs and reducing risk of development of complex systems. The Army requires an Engineering and Information System (EIS) environment or infrastructure to support the "institutionalizing" of the SBA process. The Army Materiel Command's (AMC) Major Subordinate Commands (MSCs) have Research, Development, and Engineering Centers (RDECs) which are responsible for the research and development into new and upgraded materiel solutions. Most of the RDECs have modeling and simulation tools and facilities which are used in the RDT&E process. These facilities often provide a real-time, warfighter-in-the-loop, combined arms synthetic environment to support the model-test-model and "try before you buy" approach for the RDEC's specific commodity. The capabilities include Local Area Networks, Wide Area Networks, DIS and HLA protocol-based virtual, constructive, and live simulations, data collection and analysis, visual systems, Computer Generated Forces (CGFs/SAFs), Virtual Prototyping, C4I interfaces, and others. To fully support SBD&A, and to maximize use of expertise across AMC's MSCs, these capabilities can be linked together in a common environment, and used as a form of Smart Product Model that will follow the development of the system throughout its life cycle.

**PHASE I:** Review the AMC MSC engineering level M&S infrastructure and document its capabilities to support SBD&A. Identify common engineering and information system environment components required to support SBD&A. Design a system framework which will link the RDECs M&S capabilities and provide appropriate data interactions for use in the SBD&A process.

**PHASE II:** Develop a prototype SBA Collaborative Environment (CE) consisting of an HLA-based federation of the RDEC M&S facilities and capabilities that can support SBD&A for materiel development and evaluation in a Force XXI mission context. Demonstrate the capability and functionality of the CE through a real time networked simulation exercise between the RDECs and TRAC-FLVN.

**PHASE III:** Distributed modeling and simulation environments for research, development, and engineering have immediate application to any commercial industry which could benefit from distributed development environments, e.g. automobiles, aircraft, telecommunications, etc.

**KEY WORDS:** engineering simulation, distributed simulation, simulation based design, simulation based acquisition

A99-033

**TITLE:** Aerodynamic Design Tools for Advanced Rotor Configurations

## TECHNOLOGY AREAS: Air Platforms

**OBJECTIVES:** To create new aerodynamic design tools for rotorcraft and to investigate passive and active flow-control methods using these tools.

**DESCRIPTION:** The next generation rotorcraft are required to operate in much more demanding environs than in the past, particularly in areas of nap-of-the-earth (NOE), deep-penetration, and air-to-air combat. These highly maneuverable, agile, and survivable rotorcraft must have performance levels far exceeding those in the current inventory. The most important element of the rotorcraft for meeting these requirements is the rotor itself. It is known that aerodynamic flow control can reduce vibratory loads on rotor blades caused by aerodynamic separation and dynamic stall. This would expand the rotor's stall-boundary and increase the available rotorcraft maneuvering load factor capability in all flight regimes. The rotor is also the major source of rotorcraft noise. Aerodynamic flow control on rotor blades has the potential to significantly reduce rotorcraft noise-levels. The present topic aims at the establishment of effective passive and active aerodynamic flow-control methods to improve rotor performance and to reduce noise. These controls include the use of slat/slot airfoil geometry, airfoil-profile optimization, and flow injection/suction on the blade surface. Blade flows to be controlled all involve vortex dominated regions and strong viscous interaction. In the past, design strategies for advanced rotor blades were heavily dependent on empirical studies, particularly in regimes of high angle of attack for which aerodynamic flow control offers special advantages. In recent years, significant progress has been made in understanding the important relationship between aerodynamics and vorticity dynamics in general viscous flows. The enhanced understanding has brought forth innovative approaches in theoretical aerodynamics as well as highly efficient computational and experimental methods. The Army is seeking proposals for theoretical,

computational, and experimental efforts to develop new aerodynamic designs tools for future rotorcraft and to use these tools in investigations of active and passive methods of aerodynamic flow control on rotor blades.

PHASE I. Approaches offering particular advantages for aerodynamic analysis involving vortex-dominated flows will be developed and refined. New methods capable of identifying major steady and unsteady separation zones in viscous flows will be investigated and the most promising approach will be identified. The ability of this method to provide quantitative information on key factors controlling important aerodynamic characteristics and to evaluate passive and active flow-control methods on rotor blades will be demonstrated. Airfoil profiles and aerodynamic flow control methods for which extensive performance data are presently available will be investigated to demonstrate the validity and practicality of the new method. A framework for creating aerodynamic design tools for future rotorcraft will be investigated.

PHASE II. The new method will be fully established for the investigation of three-dimensional unsteady viscous flows, covering the entire rotorcraft flight envelope and including passive and active aerodynamic flow control methods. Wind-tunnel tests and computations will be carried out to validate theoretical results. Engineering tools for rotorcraft aerodynamic design and performance optimization will be assembled from validated theoretical, computational and experimental components. These tools will be used to develop practical passive and active aerodynamic flow-control methods on rotor blades.

PHASE III - Dual Use Applications. There is a growing market for aerodynamic designs tools in a broad range of applications, including rotorcraft applications, in both the government and the private sector. The tools developed under this project are well-suited for these purposes.

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2. Larry Carr, et al, "The Effect of Compressibility on Suppression of Dynamic Stall Using a Slotted Airfoil", Presented at 35th AIAA Aerospace Sciences Meeting Jan. 12-15, 1997, Reno, NV
3. M. Chandrasekhara, et al, "Unsteady Stall Control Using Dynamically Deforming Airfoils", AIAA Journal Vol.36, No. 10, PP1792-1800
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KEYWORDS: active control, passive control, design tool, aerodynamic design

A99-034

TITLE: Enhanced Symbolology for Wide Field-of-View for Helmet-mounted Displays (HMDs)

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop novel symbolology tailored for wide FOV HMDs applicable to U.S. Army aviation missions.

DESCRIPTION: Flight at night by mediated vision, e.g., night vision goggles or FLIR sensors, is routinely performed by US Army helicopter pilots. Symbolology is usually superimposed over the outside image to assist the pilot in flight, navigation and mission tasks. The aviator's ability to perform night missions will be markedly improved by advances in Helmet Mounted Display (HMD) technology that will provide both greater resolution and a larger field of view (FOV) than currently fielded systems. The symbolology used with current systems is largely an extension of Head-Up Display (HUD) technology and is generally placed in and around the center of the display. To minimize obscuring the outside scene, the symbolology is frequently quite sparse. Forthcoming displays will offer 80 to 100 degrees horizontal FOV, providing an opportunity for innovative symbols specifically suited to these displays. This topic aims to develop such symbolology by considering its function, rendering, and placement.

PHASE I: Determine relevant characteristics of forthcoming HMD display technologies and systems. Develop realistic scenarios and task descriptions for one or two selected Army missions, e.g., transport, reconnaissance, attack, search and rescue. Perform an information requirements analysis for the tasks. Develop descriptions and dynamically prototype one or more candidate sets of symbolology for a wide FOV HMD that meets the information requirements for the mission tasks. Produce a plan for simulation-based testing of the symbolology, identifying all major design features to be assessed during Phase II.

PHASE II: Implement fully functioning real-time symbolology set(s) in a device suitable for part-task and mission-oriented testing. Complete evaluation of the symbolology set(s) developed in Phase I. Based on the results, redefine, modify and extend as appropriate the wide FOV symbolology by taking into account the availability of new information sources such as GPS, satellite communications, and data link. Extend information requirements analysis to additional Army mission scenarios.



Develop and test additional symbology sets consistent with the set(s) defined in Phase I. Based on the evaluations conducted, deliver detailed descriptions of the most promising symbology elements, including all drive functions and input requirements.

PHASE III DUAL USE COMMERCIALIZATION: The wide FOV HMD symbology will be directly useful for helicopter operations performed by the other services as well as in the civil sector. Additionally, it is anticipated that the innovations in flight guidance and navigation symbology will be useful in vision augmentation devices for the visually impaired. Some aspects of the symbology also will be applicable to automotive HUD systems.

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KEYWORDS: helmet mounted displays, flight symbology, flight guidance

#### U.S. Army Communications and Electronics Command (CECOM)

A99-035 TITLE: Mines/Unexploded Ordnance (UXO) Confirmatory System

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: To develop a chemical/biological confirmatory sensor-processing system to detect explosives in buried mines and unexploded ordnance (UXO). High probability of detection, very low probability of false alarm and moderate detection time would characterize this sensor system. This confirmatory system will be used with a set of primary detectors.

DESCRIPTION: Unexploded mines and unexploded ordnance (UXO) pose an enormous hazard both for soldiers and civilians throughout the world. Currently, there is a significant effort underway to develop equipment to detect these hazards. Most of this effort involves developing a system to detect the physical features of landmines. The goal of this research is to develop a confirmatory sensor system capable of detecting the actual explosives that make up the mines/UXO. The ideal system would have the following characteristics: A. Ability to detect femtogram amounts of the explosives; TNT, RDX, PETN, above, on or below the ground's surface. B. High probability of detection. C. Low false alarm rate. D. Real time response. E. Ability to distinguish clutter. F. Ruggedness for field environment. G. Capable of Portability and/or as part of a multi-sensor suite.

PHASE 1: Develop in the laboratory, an integrated chemical/biological sensor-processing system technology capable of detecting the explosives TNT, RDX and PETN at field-level quantities. All research must be directed towards the goals described in the above Description section. All data supporting conclusions must be submitted. Research should also include the following challenges and how they will be addressed: A. Distinguishing clutter B. Response Time C. System Purging D. System Shelf-life

PHASE II: Assemble and test the integrated chemical/biological confirmatory system in the field. The Army can provide appropriate test sites. Test with both surface and buried mines/UXO. Evaluate the following criteria: A. Sensitivity B. Clutter discrimination C. Efficiency D. Detection time E. Shelf life F. Ease of operation G. Lifetime cost.

PHASE III: DUAL USE APPLICATIONS: This technology has a wide range of opportunities. Detection of explosives is vital not only to the Defense Department, but also to the FAA, FBI, ATF and local law enforcement agencies. In addition, this technology can also be adapted for detection of other hazardous materials and be an invaluable tool for Environmental Monitoring/Remediation, NBC detection.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: This technology will benefit the Department of Defense by increasing speed, efficiency and ultimately safety in countermine and demining operations. It will also greatly benefit the Demilitarization effort.

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KEYWORDS: Chemical/Biological confirmatory sensor, detection, explosives, demining.

A99-036 TITLE: Landmine Detection

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: To develop effective techniques for the detection of buried landmines from standoff distances.

DESCRIPTION: Although significant progress has been made in recent years, the army is searching for more effective ways to detect buried land mines at standoff distances from both vehicular and airborne platforms. In particular the army is interested in techniques with the potential to meet the following requirements:

A. Airborne Mine and Minefield Detection: Detect surface and buried metallic and low metallic anti tank minefields with the following performance parameters: 1) probabilities of detection (Pd) of: a) 0.80 for surface patterned minefields b) 0.65 for buried patterned minefields c) 0.70 for surface scatterable minefields d) 0.60 for individual nuisance mines on unpaved roads 2) These Pd's should be achieved simultaneously with minefield false alarm rates less than 0.5 per km squared. Approaches which address any one or more of the minefield types are acceptable. The technology employed must have the potential for future configuration and integration on tactical unmanned aerial vehicles with payloads of no more than 65 pounds. Approaches which address the detection of anti personnel mines are also of interest

B. Vehicular Mounted Detectors: Detect surface and buried metallic and low metallic anti tank mines with a probability of detection of at least 0.9 while simultaneously achieving a false alarm rate of no more than 0.01 per meter squared. This detection performance should be achieved at a distance of 15-60 meters in front of the sensor platform. Approaches that address the detection of anti personnel mines are also of interest. Examples of low metallic anti tank mines are M19, TMA-4, VS 2.2, and TM62P. Examples of metallic anti tank mines are M15, M21, TM46, and TM-62M. Buried anti tank mines are typically at depths of 2-15 cm as measured to the top of the mine. Examples of low metal anti personnel mines include M14, VS-50, PMA-3, and the type 72. Examples of metallic cased anti personnel mines are VAL-69 and PROM1. Buried anti personnel mines are typically at depths of 1-5 cm as measured to the top of the mine. Both sensor and processing technologies are of interest.

PHASE I: Concept studies including computational and experimental components are expected. All proposed research should have a clearly articulated connection with the mine detection goals stated in the description. Sensor research should include laboratory investigations with the objective of clarifying the detection phenomenology. The research should also address how the severe clutter/target signal problem will be mitigated. Research in processing should have defined goals and quantitative measures of success.

PHASE II: These investigations must include a configuration of appropriate sensor(s) for laboratory and field experiments. Sensor investigations must include a hardware configuration that can be used in laboratory and field data collection with blind test activities included. Processing investigations must include extensive use of field data. The Army can

provide experimentation facilities that meet these data collection needs and would include field emplacement of realistic targets.

PHASE III DUAL USE APPLICATIONS: Sensor hardware and processing configurations will undergo demonstration and testing in a realistic field environment. The Army can provide test sites that meet typical testing and data collection needs that include field emplacement of realistic targets. Techniques developed under this topic are applicable to both military countermine needs as well as humanitarian demining needs. The commercial aspects of humanitarian demining are considerable. Other applications include detection of buried pipes (utility industry), buried caches, and archeological expeditions.

REFERENCES: Specific detail on each of the above mines and others is available on the "Mine Facts" CD Rom, Commander, National Ground Intelligence Center, ATTN: Tom Reeder, 220 7th Street NE, Charlottesville, VA 22902.

KEYWORDS: Mine detection, ground penetrating, buried object detection

A99-037      TITLE: Low-cost Null-steering Processor for Phased Array Antennas

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and demonstrate a low cost null steering processor for use in phased array antennas for communications on-the-move.

DESCRIPTION: The Army is developing phased array antennas for communications on-the-move. Currently these antennas are vulnerable to jamming from unwanted signals. Low cost null steering processors are required to place deep nulls in the direction of interfering signals to allow proper communications to be maintained. The overall goal is to develop a low cost null steering processor and integrate it into an existing phased array antenna to demonstrate the technology. The null-steering processor is an add-on to an existing phased array beamforming system. Additional or existing array elements are utilized to detect unwanted signals and are processed to provide modifications to the normal phase shifter settings to steer nulls in the direction of the interfering signals.

PHASE I: This program will investigate viable technologies (optical and electrical) and architectures for low cost null steering processors. The proposal should reflect knowledge of phased array antennas and the close interaction between the null steering processor and antenna. This effort may require developing innovative device technology and system architectures. Proof of concept and preliminary work will be helpful towards a Phase II program. This system should be compatible with developmental phased array antennas. The design should accurately predict expected performance parameters.

PHASE II: This continuing effort will produce a working prototype that will be tested and ultimately integrated into an existing phased array for demonstration. The emphasis of this prototype should reflect low cost, producible technologies and compatibility with existing phased array antennas. This prototype should transition very easily into production with minor changes.

PHASE III DUAL USE APPLICATIONS: Both commercial and government systems require phased array antenna systems which are resistant to deliberate or unintended interference. Inherent resistance to jamming, utilizing null steering processing, makes phased array antennas ideal for communications on-the-move.

KEYWORDS: Phased array antennas, Null steering processors, Communications on-the-move

A99-038      TITLE: Low-cost Ethernet Encryption

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Research the timeliness and availability of the extant hardware and software component base to design, develop, fabricate, and demonstrate an Ethernet level (Layer 2, Link) encryption device. This would involve the specification and layout of the required components for the device, component characteristics, electrical interfaces, Human-Machine Interfaces (HMIs), and a security kernel. Expected deliverables are a prototype device, ancillary hardware and software design specifications for the prototype, software source, instruction and maintenance manuals, and demonstration of the device's capabilities to meet the requirements of this topic.

DESCRIPTION: The DoD (and Army) inventory of encryption devices consists of Application (Layer 7), Network (Layer 3) and Link (Layer 2) devices. The Ethernet, which is a pervasive link layer protocol in strategic and tactical DoD as well as commercial applications, has no specific encryption device geared for it. In addition, most “link” layer devices lack built-in Ethernet interfaces, operate at slow speeds, or are dedicated to supporting other communications need lines. Also, Ethernet technology is advancing rapidly, for example, there is quickly developing “FAST Ethernet”, a communications protocol designed to operate at 100 MBPS (million bits per second), a ten-fold increase in speed over conventional Ethernet.

PHASE I: Generate conceptual designs for the required encryption device, review extant hardware and software component base to select the best combination of conceptual design and components to initiate design and development of a demonstration laboratory prototype. Focus of this work will be towards an Ethernet (10 Base X; IEEE 802.3)2 encryption device. Commercially available security products will be used by CECOM to test the laboratory prototype delivered at the conclusion of this Phase. A performance description and design specifications for the prototype will be provided. This work can be performed in an unclassified environment.

PHASE II: Build and expand on the Phase I work towards fabricating and demonstrating laboratory prototypes to support newer Ethernet technologies, for example Fast Ethernet (100 Base X) as well as emerging Ethernet standards (IEEE 802.11, wireless E-net)3. Show that these prototypes can be fabricated at reasonable cost. Commercially available products can be used to fabricate a prototype secure E-net to commercial standards. Investigate the feasibility to address Gigabit speed security4. A performance description or specification would be developed. Expected deliverables are a prototype device (or devices), ancillary hardware and software design specifications for the prototype(s), software source, instruction and maintenance manuals, and demonstration of device capabilities to meet the requirements of this topic. This work can be done in an unclassified environment. Phase III: It is anticipated that there will be ample commercial and military-related Ethernet security applications for the encryption device designs developed here. Caution: Offerors should be aware that the requirements of DoD-grade network security are generally more demanding than for commercial nets. Moreover, certain aspects of DoD-sponsored work may be limited to COMSEC Authorized vendors only, and National Security Agency (NSA) certification of those vendors would be required.

DUAL USE COMMERCIALIZATION: Once a commercial-grade Ethernet encryption device was successfully developed, the only change needed to make it suitable for DoD/Army use would be in the security “chips” which implement the COMSEC algorithm. That is, the initial commercial-grade security algorithm would be replaced by a DOD-grade algorithm.

KEYWORDS: Ethernet security, network security, low cost encryption.

#### REFERENCES:

1. IEEE 802.3u (FAST Ethernet Protocol)
2. IEEE 802.3 (Ethernet)
3. IEEE 802.11 (Wireless Ethernet)
4. IEEE 802.3z (Gigabit Ethernet)

A99-039

TITLE: Multicast Transport Protocols for Dynamic Wireless Networks

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: To design, specify, prototype and characterize a Multicast Transport layer protocol for the dynamic, wireless environment. The protocol must function in the dynamic hostile military environment with a minimum of communications loading, and provide reliable end-to-end, flow controlled data transfer.

DESCRIPTION: The current Internet Transport Protocol, Transmission Control Protocol (TCP), does not support reliable multicast communication. Many military and emerging commercial applications require reliable transmission to several destination machines (ie multicast operation) to properly and efficiently function. The new multicast protocol must be backward compatible with the TCP standard, and provide reliable, flow controlled communication between a set of at least 100 communicating web sites. Multicast message transfer is a critical military problem in that many, if not most data communications are required to be sent reliably to a set of receivers, and not simply point to point (single source to single receiver). The design should be capable of implementation in either a Windows NT/98 or Linux/UNIX environment. The implementation should also be compatible with the emerging DoD security equipment to provide communication in a secure environment.

PHASE I: Design and specify the protocol and provide a simulation to characterize performance in wireless environments. The design must be specified in a formal specification language such as SDL (Specification and Description Language) and clearly identify all processes, procedures, states, message formats and call flows.

PHASE II: Provide a software architecture showing the exact relationships that exist between/among all protocols, a detailed object oriented design ( in a tool such as Rational Rose or equivalent) and a prototype implementation in C++ or Java. A demonstration showing proper functional operation between up to 100 communicating sites while the nodes are executing "typical" movement such as road marches, attacking/defending, etc. The demonstration shall include receiving node failure and recovery in addition to automatic retransmission of any data sent while the receiver was inoperative.

PHASE III DUAL USE APPLICATIONS: This protocol design should become an Internet standard for the current Internet or the Next Generation Internet. All architecture and design documentation shall be released in the public domain via RFC's ( Request For Comments) technical papers, and journal articles. Implementations may be company marketable.

KEYWORDS: Protocols, networks, packet switching

A99-040                      TITLE: Display Management for Command and Control Applications

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: To provide enhanced situational awareness through automated, dynamic display management.

DESCRIPTION: As the digital battlefield matures, a new problem facing commanders will be the evaluation of information presented on situational displays. Command and control systems will have to facilitate the process of representing data in a manner which allows the intuitive commander to make rapid and effective use of digital information. Current displays of the Common Tactical Picture (CTP) are overwhelming and do not incorporate any means for the automatic placement of icons, graphics, and labels for the purpose of context sensitive situational understanding. Once digital planning is introduced, the complexity of these displays will increase greatly. Commanders need intuitive displays which incorporate the current situation, the current plan, decision points, predictive information, and more. The objective of this effort will be accomplished through the use of automatic label placement, context and temporal filtering, and customization of tactical displays. While the process of automatically creating overlays has been demonstrated, the problem of display optimization has not yet been addressed. Currently, overlay features are labeled according to static rules which compromise map legibility when multiple overlay features are present. Overlays and features need to be labeled in a manner which minimizes, if not eliminates overlap of labels, and intuitively associates names with the tactical symbols and features they reference.

PHASE I: Phase I will focus on a definition of the areas which automated situational assessment will address. The current situation, current plan, decision points for branch plans, and predictive information will be addressed at a minimum. Techniques for each area of automated situational assessment will be proposed for feasibility demonstration in Phase II.

PHASE II: Phase II efforts will address the development of the techniques identified in Phase I. These generic software applications will be incorporated into the Command and Control Directorate's C2 application prototyping environment. Prototyped software will be tested in Army Warfighting Experiments (AWEs) for soldier feedback.

PHASE III DUAL USE APPLICATIONS: Phase III of this effort will focus on a recommendation and implementation of automated situational awareness which considers appropriate commercial standards and plug and play architectural concepts suitable for insertion into future Army Common Operating Environment (COE). Each capability prototyped will be matched against COE components to identify transition targets. Designs will be developed for the insertion of automated situational awareness into these components, and software will be developed. Display management has many commercial applications including the World Wide Web. Any environment where voluminous data is integrated from a number of different sources onto one display will benefit from this effort.

KEYWORDS: Display management, automated name placement

A99-041      TITLE: Inexpensive, Micro-acoustic Sensor for Future Scout Unmanned Aerial Vehicle (UAV) Battlespace Situational Awareness Missions

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Systems are currently being sought to increase survivability of Future Scouts through the use of acoustical technologies to provide battlespace situational awareness. The objective of this task is to develop a UAV mounted micro-acoustic sensor to provide early warning, as well as enemy location and type information to the Future Scout.

DESCRIPTION: As small UAVs are integrated into the future scout mission and enter the Army inventory, lightweight, inexpensive, potentially expendable sensors will be required to perform certain missions where sensor retrieval will be impossible. One key area for such a sensor will be to provide battlespace situational awareness to the future scout. Acoustics may provide at least part of the answer to this requirement. Acoustics can provide alerting, location and identification of approaching enemy targets of interest and do so passively without degradation from dust, smoke and other visual obscuration. The system developed under this effort must be small, operate automatically and require little power for operation. The anticipated system to achieve this capability will be a device with similar physical volume and cost as a commercial paging device and will have objective ranges out to several kilometers. Placing this acoustic system onboard a UAV may provide significant advantages over a ground based system through the use of innovative location algorithms based upon the synthetically large baseline generated by the UAV movement.

PHASE I: The contractor shall design a Micro-UAV Acoustic system as described above to address alerting/location/identification of enemy ground vehicles for the future scout mission. The system shall make maximal use of existing and emerging state of the art technologies. It shall be easy to operate and require minimal troop involvement. During phase one, additional studies shall be performed to examine the unique problems and advantages of acoustics onboard a UAV including flow noise, self noise, and target sound propagation issues. Sufficient modeling shall be performed during Phase I to determine likely sensor alerting/location/identification performance values under various environmental conditions. The proposed system design shall be further refined with Government inputs during the kickoff meeting.

PHASE II: The contractor will develop, prototype, test, and demonstrate the systems designed in Phase I. The contractor shall provide at least four prototype Micro-UAV Sensor Systems as well as one ground data display for data analysis and any communications equipment required for demonstration. The contractor shall test these systems using a contractor

provided UAV surrogate and compare the measured sensor performance against expected sensor performance values resulting from the Phase I modeling efforts.

**PHASE III DUAL USE APPLICATIONS:** A potential civilian application for this technology could be a noise monitoring system at an airport or acoustical monitoring of inaccessible or noise sensitive remote areas. Such a system would be useful providing input data for environmental impact statements prior to construction or facility expansion. In addition, this system could have application in drug interdiction efforts and may be expanded to explore other targets of interest. Also, at the conclusion of the SBIR program it is possible the hardware/software may be integrated into a government UAV for further testing.

**KEYWORDS:** Acoustic,UAV,Future Scout,Detection

A99-042                      **TITLE:** Free Space Optical Communications for Ground Tactical Applications

**TECHNOLOGY AREAS:** Sensors, Electronics, and Battlespace Environment

**OBJECTIVE:** Develop and demonstrate a free space optical communication link for on-the-move tactical applications.

**DESCRIPTION:** The Army is looking at applications of high speed, secure, tactical, free space optical communication links for digital battlefield communication. These systems must be resistant to environmental conditions such as smoke, haze, rain, humidity and other obstructive medium that may impede communication. The overall goal to focus on appropriate device and system technology that will improve the state-of-the-art in laser communication. The emphasis of the program is performance, reliability, distance, and adaptability. Tracking technologies will be considered for on-the-move applications; however, some scenarios may require static positioning. Different laser frequencies and detector technology may be emphasized. Inherent resistance to jamming makes these links ideal for network backbones that may extend several kilometers.

**PHASE I:** This program will investigate viable architectures for laser communication. The proposal should reflect knowledge of the appropriate laser frequencies with respect to atmospheric absorption and scintillation effects and propose systems based on this selection. This may require developing innovative device technology. Proof of concept and preliminary work may be helpful towards a Phase II program. This design should be ruggedized in a military environment with minimal start-up time and signal acquisition. This system could be compatible with typical network topologies and ideally transparent to network protocols. This design should very accurately predict expected performance parameters.

**PHASE II:** This continuing effort will produce a working, fieldable prototype. The emphasis of this prototype should reflect advanced state-of-the-art device and systems technology operating at high speed and performance, typical of most optical communication systems. This prototype should transition very easily into production with minor changes. This system would be compatible with desired Army communication parameters as discussed during the Phase I.

**PHASE III DUAL USE APPLICATIONS:** Both commercial and government systems require links that are secure, high speed, and robust communication links. Situations may require links in which ground installation may be too costly to achieve, especially in application where the remote site is not easily accessible.

**KEYWORDS:** Laser communication, low to far infrared detectors, quantum cascade lasers, diversity reception, atmospheric propagation, high speed optical communications, free space

A99-043                      **TITLE:** Command, Control, and Communications Infrastructure Situation Awareness

**TECHNOLOGY AREAS:** Information Systems Technology

**OBJECTIVE:** Provide the commander with insight into his information system performance.

**DESCRIPTION:** As the Army digitizes to achieve information dominance, information becomes a warfighting resource, just like ammunition, fuel, and personnel. The objective of C2 systems are to provide commanders information and tools to aid in decision making. The information that the commander is provided conveys to him the current strength and capability of his force. The commander and his staff is interested in quantity and positioning of his resources. For example, when planning the next phase of a battle it is imperative for him to know that Company A is currently located at objective alpha, has lost three tanks, and has used 75% of its fuel. By knowing this type of information, the commander and staff can properly make decisions with regard to Company A. Metrics such as fuel levels, ammunition, and vehicle status have traditionally been used by commanders to make tactical decisions. In the age of information dominance the health of a units Information System (IS) is just as important as fuel or ammunition levels. In a force where information dominance acts as a force multiplier, the statue of

the IS directly impacts the combat effectiveness of a unit. Thus, it is imperative that a commander considers the level of IS capability within a unit when making tactical decisions. Just as a commander should be reluctant to attack with a unit that only has 10% of its ammunition remaining, a commander should be equally reluctant to attack with a unit that only has a message completion rate of 10%. There is a need to develop tools which can assess the health of the Tactical IS and present this data to the commander in a manner which will properly impact the commander's decision process.

PHASE I: Study Network Measure of Performance to facilitate assessing Situation Awareness. Study effective visualization techniques for displaying C3 situation awareness. Study possible software architectures for C3 infrastructure situation awareness tools which could interface with Army System Architecture. Develop proposal for building a C3 infrastructure situation awareness tool.

PHASE II: Build a prototype C3 infrastructure situation awareness tool based on the Phase I proposal. Demonstrate feasibility of a C3 infrastructure situation awareness tool in a laboratory testbed and/or through field experiments.

PHASE III DUAL USE APPLICATIONS: This system has commercial applications in any industry which depends on distributed Sensor and/or Command and Control Systems linked through a communications network. In this phase the prototype should be commercialized.

KEYWORDS: C3 systems, situational awareness, network management, performance assessment

A99-044 TITLE: Lightweight, High-power, Ground Vehicle-mounted, Gas Turbine Auxiliary Power Unit

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a lightweight, high power, vehicle mounted, gas turbine auxiliary power unit (APU) to provide power to Army fielded systems through maximal integration of Commercial Off the Shelf (COTS) components and technologies. This design goal for the APU system shall be that it weigh less 75 lbs., produce at least 10Kw, 120 VAC, 60 kHz, and 3-phase power. This APU will reduce workload for the troops through more compact and efficient power generation, increase availability of scarce space and weight budgets, and improve productivity through the use of available battlefield fuel (JP8).

DESCRIPTION: Increasing requirements for the support of the more electronic battlefield are placing ever increasing strains on the electrical power generation systems employed on the battlefield. The Army currently uses diesel generators for most of its battlefield power requirements; the diesel generator has several drawbacks to it for small-scale operations, among them size, weight, and logistical concerns. Currently, the Army has need for a high efficiency vehicle mounted gas turbine APU to run on available battlefield fuel. In developing this APU there is potential to reduce size, weight, noise, and fuel consumption through the use of new state-of-the-art technologies. In addition, to power, size and weight considerations in developing an APU for shelters and vehicles, offerors must employ novel starting solutions, state-of-the-art power controllers and develop new housing concepts to ensure troop safety considerations are addressed.

PHASE I: The contractor shall define the preliminary design of the APU, identify key components including all COTS components, and validate their design with computer simulation. In addition, during phase I, the contractor shall develop the mechanical packaging concept considering heat signature, noise, and soldier safety implications and perform thermal design and analysis on the proposed system. A study of critical system integration issues shall be performed.

PHASE II: Phase I design work will be refined and advanced, focusing especially on the fuel usage/housing/control design aspects. Electrical and mechanical design work will be completed and a full power, prototype lightweight, high power, vehicle mounted gas turbine auxiliary power unit will be fabricated. The newly constructed APU will be rigorously tested and its performance and operating characteristics will be evaluated.

PHASE III DUAL USE APPLICATIONS: Power for shelters, such as temporary ones for disaster relief and construction sites. Portable backup power systems for emergency mobile hospitals, temporary field police stations, refrigerated semi-trailer vans, etc. Power for recreational vehicles such as campers, boats, and in any other application that would require a high power to weight electric power generator.

KEYWORDS: auxiliary, power, gas turbine, shelter, vehicle

A99-045 TITLE: Soldier's Antenna

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and demonstrate an effective rugged and efficient, Very High Frequency (VHF)/Ultra High Frequency (UHF) body borne antenna for the Soldier and commercial applications.



DESCRIPTION: Present VHF/UHF antennas use effective, but high profile designs that in many instances inhibit the ability of the soldier to effectively perform his mission. These antennas when properly deployed (fully extended) tend to get caught in underbrush and tree branches. There is a need to provide the warfighter with a body borne VHF/UHF antenna that will enhance his warfighting capabilities. Efficiency and range of the antenna must be compatible or greater than legacy VHF/UHF antennas currently borne by the soldier. Consideration of emerging materials, coating, and antenna switching technologies, as well as, adaptiveness, efficiency in all warfighter positions, and the ability of the antenna to communicate in rapidly changing warfighter scenarios are critical requirements of the antenna. Successful proposals will explore and develop an innovative VHF/UHF body borne antenna system that will address these objectives and descriptions.

PHASE I: Perform a study of this requirement and develop a set of alternatives, and present to the government. The contractor and the government will make a joint decision on the most promising techniques to pursue in Phase II.

PHASE II: The most promising techniques, emerging from the Phase I study, will be further developed and modeled. A performance description, specification, and antenna prototype will be developed.

PHASE III DUAL USE APPLICATIONS: The performance description and specification will be further refined and optimized for both commercial and military use. A Soldier wearable antenna will be developed that is suitable for field testing.

KEYWORDS: communications, antennas, VHF/UHF

A99-046      TITLE: Unmanned Aerial Vehicle (UAV) Remote Sensor Control and Data Retrieval Operating Suite

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: The objective of this task is to design, develop, prototype, and demonstrate a small, light weight UAV based system which enables control and data retrieval from disposable, inexpensive, forward deployed sensors now under development. This equipment desired shall be made up of 3 subsystems: A universal sensor transmission subsystem (capable of easily operating with all sensor systems), the UAV based control and data collection subsystem, and the data reduction subsystem

DESCRIPTION: As remote sensors move further and further away from the forward line of troops, a range problem has been created for tasking sensors and collecting sensor data. It is cost or resource inefficient to provide many of these sensors with sufficient communication capability to operate continuously and to retrieve their data once it is obtained. UAV's can provide a possible solution to the range and tasking problems associated with deep remote sensors. As UAV platforms are able to be airborne for longer and longer periods of time, their usefulness as a range extension mechanism may be exploited. A PC-based computer system, in a small commercially available form factor could be used as the host for applications software that performs the mission of tasking for, and collecting remote sensor data. The UAV based system then provides the range extension and line of sight needed to retrieve the data from deep remote sensors and send it back to the ground.

PHASE I: The contractor shall design an inexpensive UAV Operating Suite with all required ancillary equipment to address remote sensor data retrieval problem. This design shall be further refined with Government requirements during the kickoff meeting. The contractor shall perform a feasibility analysis of the design and demonstrate its veracity through analysis, simulation, or other means. This analysis shall include but not be limited to: technology issues, operational issues, covert and secure operation, power, size and weight and other pertinent issues. The contractor shall also develop a test plan during phase one that will enable comprehensive testing of the device during phase II.

PHASE II: The contractor will develop, prototype, and demonstrate the UAV Operating Suite per the proposed Phase I system design. The contractor will provide a minimum of two UAV based control and data collection units, four universal sensor transmission units as well as one data reduction station to facilitate testing. The system will then be demonstrated per the proposed Phase I system test plan with surrogate remote sensors in several realistic scenarios. Phase II will be compatible with plug interfaces established under Common MOD UAV Programs.

PHASE III DUAL USE APPLICATIONS: A potential civilian application for this technology could be in the monitoring and control of sensors in inaccessible or sensitive areas such as environmentally fragile or potential danger spots where inaccessibility or line of sight considerations prevent conventional access.

KEYWORDS: UAV, remote sensors, data collection

A99-047      TITLE: Human Computer Understanding

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: To create an autonomous human computer interface which integrates multi-modal I/O technologies.

DESCRIPTION: As multi-modal interfaces mature, integration of these technologies into an autonomous human computer interface becomes the next challenge. The goal of this effort is to create a "Star Trek" like computer interface. Technologies integrated will include speech recognition, natural language processing, integrated displays, and more. The result is the application of intelligence to multi-modal technologies to control and coordinate system I/O and applications. Speech recognition software will incorporate speaker identification, and will provide a context sensitive capability. Users will be able to request data, send messages, and control displays through a voice interface. Touch and gesture interfaces, along with user identification and command context, will aid in recognition. Feedback will be provided through both display and voice interfaces.

PHASE I: Phase I efforts should focus on the selection of multi-modal technologies for integration. This selection should identify how each technology will aid in natural human understanding. A technical report should define the role of each technology and a plan for the integration and demonstration of natural human-computer understanding.

PHASE II: Phase II efforts should focus on the design and development of a natural human-computer understanding environment. Experimentation should demonstrate the effectiveness of integrated multi-modal interfaces to achieve natural understanding. A report will be produced which summarizes the results of this experimentation and recommends a design for natural understanding. This design will include when and how technologies should be integrated, as well as the software required to achieve such integration.

PHASE III DUAL USE APPLICATIONS: Phase III efforts will result in the implementation of the Phase II recommendations and design. This implementation should consider appropriate commercial standards and plug and play architectural concepts suitable for insertion into future Army COE. Transition of this implementation itself to COE will then be pursued. Natural human-computer understanding will have applicability to all DOD systems, as well as industrial and residential environments. Such a capability will facilitate the use of computers by all persons in all environments.

KEYWORDS: Human computer interfaces, multi-modal interfaces

A99-048 TITLE: Integrated Circuit and Package Switching Applications Architecture

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Investigate, analyze, design, develop and test an efficient architecture to handle the integration of tactical circuit and package switch interoperability in order to handle the convergence of voice and data networks for the tactical communications system.

DESCRIPTION: The fundamental differences between transmitting voice, video and data over circuit switching and the evolving package switching systems make it difficult for industries to develop efficient algorithms to mediate traffic between circuit and package switching systems. The commercial industries have been trying to find solutions for the problems. However, no efficient products presently exist that can provide the capability to integrate traffic between circuit and package switch applications. Recently, there are a few major industries announcing the development of new products to provide efficient methods of integrating circuit and package switching applications, however, these new techniques may not be efficiently applicable to the Army tactical networks, because there are fundamentally different network characteristics between the commercial networks and the Army tactical networks. The US Army is using both circuit and packet switched networks in almost all tactical systems. Integrating the circuit switching systems to work with the package switching systems seamlessly, and ensure the required Quality of Service (QoS) to the users is beyond state-of-the art. Therefore, a necessity exists for the Army to conduct studies, perform tests and develop reliable, efficient, and embedded schemes to enhance system operations thus evolving US Army Communications systems.

PHASE I: Conduct feasibility study and trade of analysis, which will evaluate an efficient architecture to handle the integration of tactical circuit and package switch interoperability in order to handle the convergence of voice and data networks for the tactical communications system. The study will result in an overall design plan that includes specifications of the system architecture to achieve the required objectives.

PHASE II: Develop and demonstrate a prototype system in a realistic environment. Conduct testing to prove feasibility of the system to be developed in the tactical operating conditions.

PHASE III DUAL USE APPLICATIONS: This technology will provide the industries the ability to efficiently integrate the circuit and package switching traffic by efficiently mediating traffic between circuit- and packet-switching systems. The application is critical to the Army's Warfighters Information Network program.

KEYWORDS: circuit switch, package switch, SS7, IP

A99-049

TITLE: Low-cost Attitude and Heading Reference Systems for Phased-array Antennas

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and demonstrate a low cost attitude and heading reference system for use in phased array antennas for communications on-the-move.

DESCRIPTION: The Army is developing phased array antennas for communications on-the-move. Currently these antennas utilize expensive attitude and heading reference systems (AHRS) initially designed for tanks. (The present systems utilize the Honeywell TALIN (Tactical Advanced Land Inertial Navigator) AHRS.) Currently the thrusts for developing low cost phased array antennas, leaving the AHRS as the single most costly item. Low cost AHRS are required to enable the phased array controller to determine vehicle motion (Roll + 30omin, Pitch + 30omin, and Heading 0o-360o) to allow for proper antenna beam pointing, even in the event of signal blockages during which the vehicle may change roll, pitch and heading. Angular measurement accuracy is TBD. The following dynamic rates are desired: Velocity of 45 degrees/second, Acceleration of 30 degrees/second<sup>2</sup>. The update rate required is TBD. The overall goal is to develop a low cost AHRS and integrate it into an existing phased array antenna to demonstrate the technology. Antenna beamwidths of 0.5 degree or less will be accommodated.

PHASE I: This program will investigate viable technologies and architectures for low cost attitude and heading reference systems. The proposal should reflect knowledge of phased array antennas and the close interaction between the AHRS and antenna controller. This effort may require developing innovative device technology and system architectures. Proof of concept and preliminary work will be helpful towards a Phase II program. This system should be compatible with developmental phased array antennas. The design should accurately predict expected performance parameters.

PHASE II: This continuing effort will produce a working prototype that will be tested and ultimately integrated into an existing phased array for demonstration. The emphasis of this prototype should reflect low cost, producible technologies. This prototype should transition very easily into production with minor changes.

PHASE III DUAL USE APPLICATIONS: Both commercial and government systems require phased array antenna systems for communications on-the-move. Specific applications include mobile satellite reception for truckers and radiotelephone and direct broadcast satellite reception. The development of a low cost attitude and heading reference system is critical to wide deployment of these systems in the commercial arena.

KEYWORDS: phased array antennas, attitude and heading reference systems, communications on the move

A99-050

TITLE: Advanced Intrusion Detection Techniques

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Perform research into advanced intrusion detection techniques that would utilize methods beyond the traditional pattern matching techniques currently in use.

DESCRIPTION: In both the commercial world and military world, network security is being recognized as a major emerging problem. It is vital to protect computer networks from hacker and foreign power threats. There are number of commercially available intrusion detection software packages currently available which make use of pattern matching algorithms to detect known attacks. A basic weakness of pattern matching intrusion detectors is that they cannot detect new attacks. This research will investigate new and innovative approaches to computer network intrusion detection utilizing artificial intelligence and neural networks. Specific uses of artificial intelligence and neural network technology on this project will include the examination of audit logs and the comparison of normal network traffic versus abnormal network traffic.

PHASE I: Perform a study into the application of artificial intelligence and neural networking techniques towards computer network intrusion detection. A set of alternatives would then be presented to the government. The contractor and the government would make a joint decision on the most promising techniques to pursue in Phase II.

PHASE II: The most promising techniques emerging from the Phase II study would be further developed and modeled. A performance description or specification would be developed. A prototype software working model will be delivered.

PHASE III DUAL USE APPLICATIONS: The performance description or specification would be further refined and optimized for both commercial and military use. Depending on findings, the commercial specification may vary in certain ways from the military specification.

KEYWORDS: intrusion detection, artificial intelligence, neural networking

A99-051            TITLE: Hybrid Pixel Miniaturization

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: To develop an interconnection (bonding) technique between a detector array and read-out integrated circuit array such that the individual pixel size is less than 12 microns by 12 microns. The goal is a hybridized pixel size approximately the same as a CCD pixel. The technique would normally bond a silicon read-out with an array of MCT detectors and operate in the wavelength region of visible to 2.5 microns.

DESCRIPTION: Modern etching techniques have successfully reduced the size of infrared sensing detector pixels to the point where a substantial barrier in further reduction of pixel size is the size of interconnection bond between the detector element and the read-out circuit. The goal of this effort is to reduce the pixel size of hybridized focal plane array.

PHASE I: Develop and evaluate an electrical interconnection method that results in detector pixels that are less than 12 microns by 12 microns in area.

PHASE II: Assemble a hybridized near infrared focal plane array with pixel pitch of less than 12 microns in a 1280 by 1024 format with a fill factor approaching 100%.

PHASE III DUAL USE APPLICATIONS: Hybridized focal plan arrays are currently the standard in virtually all high performance infrared imaging applications. All surveillance, radiometry, security applications could benefit from smaller pixels as a result of package size reduction, and reduced power consumption.

KEYWORDS: NIR, SWIR, FPA, Uncooled

A99-052            TITLE: Automatic Signal Exploitation

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Research, develop and design practical implementations of automatic modulation classifier and blind demodulators to a set of channel waveform modulations such as quadrature amplitude modulation, in modules of C, C++, and Very high speed integrated circuit Hardware Description Language (VHDL) codes, that enable to be ported to generic computers and commercial hardwares such as Digital Signal Process (DSP) and Field Programmable Gate Arrays (FPGA) chips.

DESCRIPTION: A need exists for the rapid prototyping and implementation of blind demodulators which are robust to a changing tactical environment. A system is needed that facilitates research into high-level algorithm development while simplifying porting of the newly designed algorithm to C code suitable for real-time operation on DSP chips or to HDL/VHDL code for FPGA implementation. The system must support both simulation and system integration.

PHASE I: Identify promising algorithms for blind demodulation from research literature, and conduct research on developing new approaches. Conduct simulations to test the performance of the algorithms.

PHASE II: Design practical implementations of algorithms in C and HDL/VHDL codes. Develop a Graphical User Interface (GUI) platform in PC environment to demonstrate the capability of porting implementation designs onto commercial hardwares.

PHASE III DUAL USE APPLICATIONS: Such development platform and algorithm tools will facilitate both commercial and military users to analyze signal waveforms in diverse unknown environment.

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KEYWORDS: blind demodulation, signal analysis

A99-053

TITLE: Rangefinder/Illuminator Read-Out Integrated Circuit (ROIC)

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: To develop a Near Infrared (NIR) detector array readout integrated circuit (ROIC) that will permit gated imaging of a target illuminated with a pulsed laser source at 1.5 to 2 microns. The ROIC shall gate the detector arrays to integrate the received illumination for a time period of 0.1 to 20 microseconds after a variable delay time from the laser pulse. The range to the target will be from 500 meters to 5 kilometers. The NIR detector array (MCT or InGaAs) will be a 1000x1000 array with pixel pitch on the order of 12.5 microns. The ROIC shall also operate in a normal framing mode at a 30 Hz rate.

DESCRIPTION: Currently there is no range gated ROIC operating in the 1.5 to 2 micron range. The goal of this effort is to develop the ROIC for a NIR detector array, which is currently being developed to operate < 2 microns.

PHASE I: Develop and evaluate circuits that result in gated pixels in square area of less than 12.5 microns on a side.

PHASE II: The contractor will assemble and deliver a prototype 1000x1000 ROIC with a 12.5-micron pixel pitch with the center 100x100 pixels on the ROIC having the range gating capability. The ROIC will be suitable for integration with a solid state 1.5 to 2 micron detector array.

PHASE III DUAL USE APPLICATIONS: Techniques developed under this topic are applicable to both military and commercial applications. All surveillance, radiometry, security applications could benefit from an uncooled, NIR camera. Commercial applications for this technology include medical and dental imaging; spectroscopy for atmospheric monitoring; astronomy; active imaging systems for search and rescue operations; police applications and border patrol use to identify ships or vehicles.

#### REFERENCES:

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4. <http://tcs.thomson-csf.com>,
5. <http://www.ccd.eev.com>,
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KEYWORDS: NIR, Uncooled, ROIC, Active Imaging

A99-054

TITLE: Laser Protection Device for Near Infrared (IR) Optical Devices

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: To develop a concept which will pass low energy light in the near IR, but blocks high energy light. Only self-healing concepts with non focal plane requirements will be considered.

DESCRIPTION: The US Army is seeking concepts which will protect Near IR sensors such as Night Vision goggles and low light televisions against Laser radiation. These devices operate over the wavelength range of 600 to 900 nm and both, out of band and in-band protection are required. Innovation technological approaches are sought for protection against multi-wavelength pulsed Laser devices. Emphasis should be placed on minimizing the impact on the operational capability of the device and on maximizing the transmission in the 600 to 900 nm range, while still giving protection.

PHASE I: Demonstrate proof-of-principle

PHASE II: Fabricate, test, demonstrate and deliver a minimum of ten elements that meet the goals set forth.

PHASE III DUAL USE APPLICATIONS: Protection of the eye from Laser radiation are needed in a wide variety of Laser applications including industrial, medical, dental and communication activities. Dual Use Application of the Laser Protection Device is the goal of Phase III.

REFERENCES: US Patent 5831769.

KEYWORDS: Near IR, Pulsed, Multi-wavelength, laser protection

A99-055

TITLE: Solid State Infrared (IR) Chopper for Uncooled Infrared Camera

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: The objective of this topic is to develop an IR solid-state chopper for pyroelectric/ferroelectric and bolometric (high dynamic scene scenarios) IR uncooled cameras. Presently mechanical choppers add weight, size, input power, and cost to uncooled IR cameras. Also, since the time constant of the chopper and detector are equal; it reduces the signal by a factor of two. The chopper shall be designed such that it operates less than half the frame rate so that as much incoming radiation is absorbed as possible. The time constant of the chopper shall be consistent with the above, so that signal collection is maximized.

DESCRIPTION: The solid state chopper shall be designed for uncooled ferroelectric/pyroelectric and bolometric detectors that are 25 microns in pitch. The chopper shall operate at frame rates from 30-60 Hertz and have a small duty cycle. The chopper shall have a reliability of at least 10,000 hours of camera operation and consume minimal average power. Implementation of the concept should not add to the size or weight of the camera to any measurable degree. The concept should also be capable of withstanding large accelerations (up to 10,000 g's) so that the cameras would be able to be air dropped.

PHASE I: Develop a new concept for chopping radiation with no mechanical parts and analyze camera performance.

PHASE II: Build a small 25-micron uncooled array with the new chopper and demonstrate performance.

PHASE III DUAL USE APPLICATIONS: Techniques developed under this topic are applicable to both military and commercial applications. All surveillance, radiometry, security applications could benefit from uncooled, IR camera.

KEYWORDS: Uncooled, Solid State, Chopper, Pyroelectric/Ferroelectric, bolometrics

**U.S. Army Cold Regions Research and Engineering Laboratory (CRREL)**

A99-056

TITLE: Preflight Deicing and Anti-icing of Helicopters

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop capability of preventing or removing ice and snow from helicopter surfaces that must be clean prior to flight including but not limited to rotor head, main rotor blades, tail rotor, engine inlets, windshields, avionics and weapons systems. Snow and ice prevention is preferred, but removal of ice and snow is also of high priority when prevention methods fail or are not available. Prevention or removal systems should require no modification of the helicopter, and it is desirable that systems be portable (preferably flying with the helicopter for continuous availability), compact, lightweight, inexpensive and sufficiently robust for field use with minimal training. Methods should not be mechanical, such as scraping of ice from surfaces, and should not overheat, nor rapidly heat and cool, aircraft composites. Systems are also required that may be transported by helicopter or HMMWV to temporary airfields, assembled, and used for deicing many aircraft, but that do not have to be carried with the aircraft. Fluids must be compatible with military requirements including corrosively and flammability, and must be sufficiently benign environmentally to not require capture or remediation. It is desirable that systems include a wide-area ice imaging system to allow ice to be observed on the aircraft, even at night, and to evaluate the thoroughness of snow and ice removal. Systems should remove ice and snow, or prevent ice and snow, sufficiently to allow an aircraft to safely fly.

DESCRIPTION: Procedures for preflight de-icing of helicopters have not been refined nor standardized as they have been for fixed-wing aircraft. One reason may be because helicopters are typically hangared. In the military, however, helicopters are often exposed to weather when garrisoned in the field allowing freezing precipitation and snow to accumulate on airframe and blade surfaces. Snow and ice often adheres after skies clear, grounding aircraft for hours to days, unless frozen contaminants are manually removed. Modern helicopters are more likely to be damaged by casual ice removal techniques than are fixed wing aircraft because large portions of rotor blades and fuselage surfaces are constructed of composites. Composites are susceptible to damage from physical impact, scraping, high temperatures and thermal cycling. In addition, helicopter rotor heads are vulnerable to corrosion and damage from washing of lubricants from bearings when glycols are used for de-icing. Infrared radiation, hot water and hot air have been used to experimentally de-ice helicopters before flight. Infrared systems are promising and are used operationally to deice fixed-wing aircraft. However, current systems are not transportable on helicopters, and have the potential to overheat composites. Hot air de-icing systems typically draw air from an independent heater through a manually operated hose and nozzle to melt ice. Hot air systems are currently slow, cumbersome for personnel to use, and have the potential for overheating composite blades or causing rapid and potentially damaging thermal cycling of composites. Systems involving covering aircraft with tents or parachutes and filling with hot air are very slow and cumbersome. Commercial fixed-wing aircraft are typically deiced with environmentally-damaging glycol-based fluids. Glycol-based deicers are unacceptable for use on

helicopters, especially rotor heads, where lubricants can be washed away and corrosion started. Hot water also can remove lubricants if used under high pressure, and may refreeze on cold surfaces causing larger residual ice problems than did the original ice or snow deposit. Ice prevention has been accomplished using portable covers for aircraft surfaces, such as blades, engine inlets, wind screens and rotor heads. Covers are portable, compact and useful when used before ice or snow is deposited. However, they are also expensive, and require that an aircraft is completely dry before installation, otherwise they may freeze to blades and other structural components. Ice-phobic coatings may assist ice removal. However, coatings do not prevent ice accretion, or alone do they cause ice and snow to be removed. Ice-phobic coatings also erode easily, may complicate decontamination procedures, and typically have required frequent renewal to be effective.

PHASE I: Demonstrate feasibility of developing system for preventing or removing ice and snow from helicopter surfaces sufficient for flight. Systems are desirable that can be easily transported with each helicopter, or transported to, assembled and stationed at temporary airfields by helicopters. The system should be compatible with Army helicopters, preferably all models, present no hazard to aircraft, personnel or the environment, and utilize no mechanical methods, such as scraping, for removing ice. The system should be capable of removing ice and snow of any type or thickness from a helicopter within one hour or less sufficient to make the aircraft safe for flight. The system should be transportable by helicopter or HMMWV, preferably fly with each helicopter, weigh less than 4000 lbs. and occupy a space no larger than 84" wide by 84" long and 72" high. Liquid fuel, if required, must be JP-8. Electrical power cannot be drawn from helicopters, but helicopter APU bleed air may be used. Provision must be made for efficiently capturing and disposing of environmentally-damaging fluids. Expected cost and maintenance should be assessed and should be minimal.

PHASE II: Design and construct prototype deicing/anti-icing system conforming to requirements established in Phase I and demonstrate in field tests representative of battlefield conditions. The developer should be prepared to work with the Army in developing a plan to test and evaluate the system under a wide variety of ice and snow conditions encountered by Army helicopters and crews in battlefield operations. Pending availability of the requisite Army assets, limited testing with Army helicopters and crew personnel might be conducted. Short of this, the testing should approach operational battlefield scenarios as closely as possible. Phase II deliverables will include prototype system hardware and software, prototype design and system performance documentation, available user/maintenance/trouble-shooting documentation, and projected cost data for pilot manufacturing runs.

PHASE III DUAL USE COMMERCIALIZATION: Military and commercial helicopters, and fixed wing aircraft operating in the far north and in areas without support facilities such as servicing offshore oil rigs, need such systems. Systems would extend operating conditions for all-weather helicopters, improve safety and reduce the time required to pre-flight helicopters after ice or snow events. A system would be considerably less expensive than the cost of hangaring aircraft, and would reduce damage to expensive, safety-related helicopter components caused by the use of improper deicing procedures. The system may also be useful for deicing UAVs and fixed-wing military and commercial aircraft.

REFERENCES: Society of Automotive Engineers, 1987, Icing Technology Bibliography. Aerospace Information Report, AIR 4015, SAE, Warrendale, PA, 149 p. Ryerson, C, T. Gilligan and G. Koenig, 1999, Evaluation of Three Helicopter Preflight Deicing Techniques. AIAA Aerospace Sciences meeting, January, Reno, 99-0499, 6 p. Baca, A., and C. Herring, 1996, Minutes of Aircraft/Runway Deicing/Anti-icing Technology Crossfeed. Air Force Materiel Command, Wright-Patterson Air Force Base, AFMC-TM-96-9002, 476 p.

## **U.S Army Chemical Biological Center of Excellence (CBCOE)**

A99-057      TITLE: Synthetic Receptors for Reagentless Biosensors

TECHNOLOGY AREAS: Chemical/Biological Defense and Nuclear

OBJECTIVE: To develop molecular 'imprints' in a polymer matrix which can selectively bind chemicals, toxins and/or bacteria. The development of polymer imprints which exhibit similar antigen binding properties as antibodies offer significant advantages over the latter in their simple and rapid preparation methods, chemical, mechanical and thermal stability and potential for repeated use.

DESCRIPTION: Biodetectors currently rely on biological recognition sites such as monoclonal antibodies, genetic probes, enzymes and other receptors which require an aqueous environment for proper function. This necessitates extensive "plumbing" and environmental controls to maintain stability and function of the biological reagents. Artificial receptors made from synthetic polymers would recognize biological agents (i.e., pathogens and toxins) with high affinity and specificity and would function under extremes of temperature and in a dirty environment.

PHASE I.    1. Develop and test procedures for imprinting large MW compounds.    2. Synthesize and test polymer casts from large MW toxins (Ricin and BoTX).



PHASE II. 1. Assess specificity and affinity of imprinted polymer(s) for toxins. Compare with antibodies. 2. Test feasibility of polymer casting for 'whole cell' imprints. 3. Develop requirements/configurations and test polymer imprints in different sensor formats. 4. Produce gram quantities for use on sensors and test kits.

PHASE III DUAL USE APPLICATIONS: 1. Medical diagnostics 2. Environmental monitoring 3. Industrial process control 4. Drug design 5. Military biological point detection 6. Specific Molecular absorbants

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The use of purely synthetic molecular recognition elements would significantly reduce the logistics in production and storage of reagents derived from biological sources.

REFERENCES: Haupt, K and Mosbach, K. Plastic antibodies: developments and applications. Trends in Biotechnology, Vol. 16, pp 449-489. Aherne et al., J. Am. Chem. Soc., Vol. 118, pp. 8771-8772, 1996.

KEYWORDS: receptors, molecular imprints, polymers, detectors, biosensors

A99-058 TITLE: Microfabrication-based Biodetectors

TECHNOLOGY AREAS: Chemical/Biological Defense and Nuclear

OBJECTIVE: Reduce the size, sample, and power needs of biodetectors using microfabrication.

DESCRIPTION: Microfabrication methods offer the possibility of producing biosensors and biodetector components of unprecedented smallness (i.e. chip based) as well as enabling novel designs, chemistries, and general biosensing approaches not possible in macrofabricated systems. Biological detection goals include deployment of microfabricated sensor systems that are capable of processing and analyzing microliter amounts of sample for a variety of threat bioagents: toxins, viruses, and bacteria. Ideally, such systems would include microfabricated pumps, actuators, sensing platforms, fluidics manifolds, detectors, sample isolators, and sample concentrators; all linked and automated into a continuous process on a hand-held type of system. They would be able to take sample from the macroworld and process and analyze it in their microfabricated environment. Of particular importance for this topic is research and development of microfabricated sensing platforms, sample isolators (from a matrix or interferents), and sample concentrators. Phase I. A successful Phase I effort will be one where the feasibility of applying microfabrication technology to aspects of the biosensing problem are demonstrated. Topics for consideration include the three areas listed at the end of the DESCRIPTION above. The topic calls for more than an engineering effort - concept demonstration must be tied to an actual biochemical system of the proposer's choice, i.e. detecting or isolating a toxin, virus, and/or bacteria sample. The Phase I work does not have to show automation (although desirable) but must show proof-of-principle of the fundamental processes in a microfabricated environment. Specific research objectives are:

a. Develop and test microfabricated sensing platforms that are capable of processing and identifying toxins, viruses, and bacteria in 100ul or less amounts. DNA, antibody, and physical based methods are all candidates for consideration. Detection and identification of multiagent types is desirable but is not a topic criteria.

b. Develop and test microfabricated and rapid (less than 10 minutes) sample isolation systems that are capable of processing 500ul and less amounts of toxins, viruses, and bacteria. Processing functions fall into two areas either or both of which the proposer may address. First, there is bulk isolation of the specific biomaterial from the sample matrix. Second, there is isolation of DNA from its organism and its separation from or neutralization of interferents and inhibitors prior to analysis (i.e. by the polymerase chain reaction). Rapid lysis and DNA extraction from spores is particularly important. Samples will be non-medical and must be taken from or mixed with an actual environment such as soil, polluted water, smog filled air, indoor surfaces, and vegetation. Systems that are capable of processing more than one biomaterial type are desirable but not mandatory for this topic.

c. Develop and test microfabricated and rapid (less than 10 minutes) sample concentration systems that are capable of processing 100ul and less amounts of toxins, viruses, and bacteria. The goal of this work will be to take dilute levels of biomaterial and concentrate it to levels that are orders of magnitude higher in the same 100ul volume. Although not binding, examples are: for bacteria  $10^2$  to  $10^4$  CfU/ml, for viruses  $10^2$  to  $10^5$  PfU/ml, and for toxins B pg/ml to ng/ml. Phase II. Phase II will optimize and expand the technology and methods demonstrated in Phase I and automate them in a modularized microfabricated configuration. A solid and realistic commercialization plan is essential. Continuance of the effort will depend on the proposer's success in this area as well as technically.

PHASE III DUAL USE APPLICATIONS: 1. Medical diagnostics 2. Industrial monitoring and process control 3. Environmental pollution assessment 4. Military biological field detection. 5. Military personnel and area disease monitoring. 6. Domestic preparedness.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Microfabricated sensors which meet the military's sensitivity and specificity goals would be cheap (possibly to the point of being disposable), take up less space, weigh less, and most likely be easier to operate. All this will serve to lower production and training costs.

KEY WORDS: Microfabrication, microsensors, biosensors.

REFERENCES: Review the last two to three years of Analytical Chemistry to start.

#### **U.S. Army Missile Research, Development, and Engineering Center (MRDEC)**

A99-059      TITLE: Small, Low-cost GPS Anti-jam System

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a small low cost anti-jam system that uses a single element dual frequency antenna for use in small precision guided missiles.

DESCRIPTION: Current GPS anti jam technology utilizes multi-element antenna array with large antenna electronics. The initial tracking and suppression of a jamming signal is currently slow (>50 ms). This slow response is inadequate for use by small high dynamic precision guided missiles and munitions. Missiles such as Guided MLRS and ATACMS need a system must be able to track and suppress the jamming signal within 10 milli-seconds. Small precision guided missile/munitions can only accommodate a single element antenna. The goal of the anti-jam system is to provide greater than 30-dB protection from single and multiple continuous wave, broadband noise (20Mhz), and pulsed jamming signals. All army systems utilizing GPS could benefit from this topic.

PHASE I: Design an anti-jam system. The size goal of the antenna electronics is a 4x4x1 inch card. The antenna must be a dual frequency single element antenna. The goal for the signal acquisition and suppression time is less than 10 milli-seconds.

PHASE II: Build a prototype system of the design from phase I using best commercial practices. The government will conduct all field and laboratory testing.

PHASE III DUAL-USE APPLICATIONS: The use GPS receivers are becoming widespread on many commercial aircraft. The airwaves are being crowded with various transmitters from radio stations, television stations, and cellular phone networks that could cause commercial GPS receivers to be inadvertently jammed. This device could reduce and possibly eliminate the GPS receiver on commercial aircraft from being jammed.

REFERENCE: NAVSTAR GPS Space Segment ICD-GPS-200, GPS Joint Program Office, September 1997

KEYWORDS: GPS receiver, anti-jam, adaptive null antenna

A99-060      TITLE: Liquid Crystal Polymer as a High-density, High-Reliability, Electronic Substrate Material

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and validate manufacturing processes for Liquid Crystal Polymer as a high density interconnect substrate for electronics applications.

DESCRIPTION: As electronic assemblies increase in density due to advances made in semiconductor fabrication technology, the ability for standard FR-4 printed circuit boards (PCBs) to route all the interconnections between integrated circuits on a printed wiring assembly is approaching significant limitations. Mass production of PCBs with line/space pitches less than .005 inches are needed but are not generally available at reasonable cost. Circuits operating in the GHz regime need a lower dielectric constant than FR-4 to efficiently carry the high frequency signals. In addition, with a glass transition temperature of approximately 150 degrees C, FR-4 is marginal for high temperature applications. In contrast, liquid crystal polymer (LCP), a relatively new material, has excellent electrical and thermal characteristics (approximately 3.0 dielectric constant, 350 degrees C glass transition temperature, coefficient of thermal expansion similar to silicon), and appears to be very amenable to mechanical and chemical processing. Of critical importance in achieving widespread acceptance - the material also appears to be nearly as low cost as FR-4. What is needed is processing development, performance verification, and economic analysis to determine if LCP is a valid material for electronic substrate applications.

PHASE I: Survey supplier base and formulations of LCP for availability as an electronic substrate. Characterize material electrically, thermally, and mechanically. Process using standard PWB/flex circuit fabrication techniques. Document required process changes and material engineering is needed for optimum performance at lowest material and processing cost. Determine limits in terms of signal trace density, number of layers, thickness, and via diameter/aspect ratio. Perform analysis to determine most applicable PWB market segment (ex: chip scale package redistribution layer, ball grid array substrate, Personal Computer Memory Card International Association-type substrate, high density interconnect, etc.) based on performance/cost benefits. Fabricate test vehicles, populate with components, and perform baseline electrical and environmental tests against FR-4 control boards.

PHASE II: Develop and test new process for low cost fabrication of LCP substrates using as much of the electronics fabrication industry infrastructure as possible. Develop test and quality control procedures. Determine costs for installation and start-up of a dedicated fabrication line. Demonstrate the new substrate technology in a test vehicle approved by the Institute for Interconnecting and Packaging Electronic Circuits (IPC) and Interconnect Technology Research Institute (ITRI). Submit 10 substrates (5 populated) to the Government for independent reliability testing. Develop commercialization plan and investigate commercial marketing with industry partner. Present results at an IPC workshop or conference.

PHASE III DUAL-USE APPLICATIONS: This substrate technology is needed in the military for all lightweight, processing intensive applications such as missile seeker target processing/guidance and control, avionics, and manportable weapons/communication systems. Potential commercial markets are much larger and include portable electronics such as cellular phones, laptop computers, camcorders, and personal digital assistants.

#### REFERENCES:

1. "Liquid Crystal Polymers and Their Role in Electronic Packaging", K. Jayaraj, et al, Advancing Microelectronics journal, July/August 1998, p. 15-18.
2. "A Low-Cost Near Hermetic Multichip Module Based on Liquid Crystal Polymer Dielectrics", Thomas E. Noll, et al, Proceedings from 1996 International Conference on Multichip Modules, Denver, Colorado.
3. "A Low Cost Multichip Packaging Technology for Monolithic Microwave Integrated Circuits", K. Jayaraj, et al, IEEE Transactions on Antennas and Propagation, Vol. 43, No. 9, September 1995.

KEYWORDS: liquid crystal polymer, printed circuit board, chip scale package, high density interconnect

A99-061

TITLE: Alternative Liner Materials for Main Charge Warheads

TECHNOLOGY AREAS: Weapons

OBJECTIVE: The objective of this SBIR is to identify promising alternate liner materials and designs for main charge warheads used in missile and rocket applications. It is known that some liner materials are more efficient at penetrating materials in multilayer, non-homogeneous targets than conventional copper penetrators. Other advantages can include pyrophoric effects, increased spall generation and increased hole diameter. The desire is to be able to integrate this technology into current and future Army missile systems. Dual-use applications for this technology can be found in the oil well, mining, and law enforcement industries.

DESCRIPTION: The US Army uses some conventional metal liners such as copper, tantalum, and molybdenum for use in main charge warheads. This SBIR will look at alternate materials that could be used as a liner for main charge warheads. The intent is to increase the performance of current main charge warheads and to increase understanding on what materials best defeat threat armors.

PHASE I: Identify candidate materials. Perform research and analysis on how to process and manufacture the raw materials to obtain ductility and strength. Model the warhead using analytical and hydrocode models to optimize performance. Develop trade-offs to determine the maximum thickness and contour of the liner, explosive output, etc.

PHASE II: Raw material purchase, metallurgy, and processing. Manufacture liners and press into billets for performance testing. Perform design iterations until the performance of the main charge is maximized. The test data will be analyzed to determine the effectiveness of the main charge compared to a baseline. Tandem warhead applications will be considered in this effort.

PHASE III DUAL-USE APPLICATIONS: Once Phase II is completed and the test data analyzed a decision will be made if the performance is enhanced enough to go into production as an option for lethality enhancement to a missile system. During Phase II, the oil well logging services, mining industry and law enforcement services would be briefed on the findings for potential use in their applications. The oil well industry is concerned with better perforation of rock and water filled structures. The military role of perforation of multi-layered targets of various materials is a common theme for their performance requirements. Additionally, the mining industry uses shaped charges to create boreholes that are used for cratering

charges. Maximizing the diameter and depth of penetration reflects the problems associated with military applications. Law enforcement applications are common to military ones because of the nature of the targets that they wish to breach.

KEYWORDS: Alternate materials, warheads, explosively formed penetrator's, shaped charges, and liner materials.

A99-062 TITLE: Internet Solutions for Information Integration

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Establish the feasibility of satisfying evolving, information integration battlefield functions using government and commercial internet-related technologies.

DESCRIPTION: Recent digitization experiments have demonstrated that fundamental changes to battle staff operations is required to reap the full battlefield effects of long range sensor and weapon system combinations when under the direct command and control of light, tactical force commanders. This is principally due to the fact that tactical control of longer range, real time sensors: (1) extends the battlespace to include a deep battle area, in addition to the traditional, main battle area, thus increasing the overall volume of targeting and damage assessment information to be managed by the battle staff, and (2) provides direct support for indirect fire weapon systems, thus transitioning the sensor management function into a pro-active, time-critical role. This leads to an increased emphasis on information integration battlefield functions that manage critical sensor and weapon information in a manner that allows immediate comprehension, assessment, and resulting force direction. The problem stated above, is not dissimilar to that presented to and solved by large, commercial operations each year, for they also need information integration capabilities that allow them to manage their business information in a way that allows immediate comprehension, assessment and decision-making. However, technical solutions for business have generally required medium to high communications bandwidth and commensurate processing environments. The internet has changed this solution paradigm. Over the past two years, internet related technology companies have increased their investment in low bandwidth, low cost internet solutions that may lend themselves to support information integration battlefield environments. Innovative research is needed to investigate the feasibility of applying evolving internet-related technologies to the tactical battlefield environment. Viable candidates will be demonstrated in a battlefield test environment.

PHASE I: Identify the information integration functions that are in common between the business and battlefield domains. Establish the tactical environment constraints and define the evaluation criteria. Identify government and commercial internet-related technologies that can support these information integration functions. Perform a feasibility assessment. Identify a "tailored" technology solution set(s) that are feasible for the tactical battlefield environment. Identify the specific Battlefield Operating System (BOS) area to which the solution set will be applied in Phase II. Develop the Phase II Plan.

PHASE II: Acquire and integrate the internet technology solution set and integrate with the specific BOS area software/hardware. Identify candidate demonstrations/experiments opportunities and execute the Phase II Plan to include the development of a detailed experiment plan that addresses experiment design, experiments to be executed, data to be collection and analyses to be performed. Execute the experiment, perform analysis on the collected data, and publish the results in a final report.

PHASE III DUAL USE APPLICATIONS: Any low-bandwidth internet technology solution has potential application across all Battlefield Operating System (BOS) areas. Each BOS area may have a commercial counterpart, e.g., "operations" has information integration functions that are common to both domains.

#### REFERENCES:

1. "Gates Talks About PCs, the Internet, and Globalization at the World Economic Forum"; PRESSPASS: <http://www.microsoft.com/presspass/features/1999/02-01davos.htm>; 01 FEB 1999.
2. "Moving JAVA to the Factory"; Robert W. Atherton; IEEE Spectrum Magazine, Vol. 25, No. 12; December 1999.
3. "Military Operations Future Operational Capability", TRADOC Pam 525-66; Department of the Army, Headquarters U. S Army Training and Doctrine Command, 01 May 1997.
4. "Army Digitization Master Plan '96"; U.S. Army Digitization Office; March 1996 N/A

KEYWORDS: information integration, internet, browser, web, multi-media, information management, data compression, tactical communications

A99-063 TITLE: Object Tracking through Rapid Sensor Orientation Change

## TECHNOLOGY AREAS: Weapons

**OBJECTIVE:** The objective is to develop an algorithm for tracking an object through rapidly changing sensor orientation. When the sensor is in motion, the background behind the object can change significantly making an object difficult to track. This is particularly difficult when the relative target/background polarity changes ( i.e. light object on dark background becomes dark object on light background and vice versa) or the object is difficult to distinguish from the background. This algorithm shall be developed with the potential for future real-time hardware implementation in a missile.

**DESCRIPTION:** The application of this algorithm will be focused but not limited to Imaging IR missile target tracking for top attack ground target scenarios. Current missile applications frequently use imaging sensors and tracker lock on before launch to destroy their targets. In some cases it is necessary to have a top-attack scenario to insure an appropriate kill ratio. This top-attack scenario requires that the missile climb rapidly after launch to achieve an appropriate altitude. This rapid climb out scenario can cause drastic changes in the perceived target orientation and background. Innovative new ideas are needed to help insure that trackers can maintain target lock through this rapid sensor orientation change.

**PHASE I:** Develop innovative new algorithmic approaches to object tracking through rapid sensor orientation change. This algorithm is intended for but not limited to use with existing IR imaging sensor hardware for top attack ground targets. A series of IR image sequences from captive flight tests and/or simulation runs will be made available to the contractor for development. The contractor will demonstrate the capability of the new algorithm against a second set of data and provide a report documenting the algorithm and results.

**PHASE II:** The contractor will implement the algorithm in Cor C++ software for inclusion into simulations for further testing. The contractor will develop a plan for hardware implementation.

**PHASE III DUAL-USE APPLICATIONS:** This technology will be used to improve target tracking capability for missile target trackers and also has numerous commercial applications. Commercial applications include: Automated Inspection, Autonomous guided vehicles, and Vehicle tracking. Some references in support of commercial applications in these areas can be found at the following web locations: [http://www.sees.bangor.ac.uk/users/dewi/otcs\\_web.htm](http://www.sees.bangor.ac.uk/users/dewi/otcs_web.htm) Documents the need for an automated tracking system to track a stationary object from a plane or helicopter for power line inspection <http://www.neuroinformatik.ruhr-uni> Documents the need for a system to estimate the positions and danger potential of other objects for an autonomous vehicle <http://www.vision.caltech.edu/koller/ModelTracking.html> Documents the difficulty of tracking traffic in road scenes. <http://vision.caltech.edu/koller/MOU-83.html> Documents the need for a vehicle tracking system that runs in real time.

**KEYWORDS:** imaging, missile target tracking, top-attack, lock-on-before-launch, close combat, polarity reversal

## U.S. Army Medical Research and Materiel Command (MRMC)

A99-064      TITLE: Development of a Personal Environmental Recording System for Monitoring Shock, Motion, and Physiology of Soldiers Wearing Head-mounted Devices

## TECHNOLOGY AREAS: Biomedical

**OBJECTIVE:** Develop a miniaturized personal environmental recording system (PERS) to monitor and store electromyographic data, head/torso posture, and head impact response of soldiers participating in military operations. The system will be used to quantify the exposure environment of soldiers wearing full combat gear plus various helmet-mounted devices (HMDs). The collected data will form a basis for estimating head and neck musculoskeletal injury risks and for prediction of fatigue thresholds in operational environments.

**DESCRIPTION:** The U.S. Army has an urgent need to accurately monitor and record head impact, upper body dynamics, head posture, and physiological signatures from soldiers operating in harsh military environments. These include running, jumping, ingress and egress from air and ground vehicles, unexpected fall, and parachute opening shock. An inexpensive device is needed to record data from different types of sensors attached to the soldier. The device must be small, lightweight, robust, and self powered with no external cabling to allow the system to be worn by soldiers as they conduct field exercises. Potential sensors include EMG electrodes, accelerometers and angular rate transducers, and relative position sensors. Data may be stored on a soldier-worn device or sent via telemetry to a secondary recording unit. Required signal conditioning and data acquisition modes are sensor and application dependent. The requirement for an integrated PERS, which does not interfere with the soldier's activity, and its use in harsh military environments pose unique challenges that require design innovation. An additional technical challenge is presented by the need to sense, condition, collect and store accurate data, simultaneously in different acquisition modes. Because of the technical risks associated with these challenges, no similar system has been

commercially developed. It is essential that the data collected allow accurate biodynamic reconstruction and synchronization with the physiological data. Automated analysis software must be developed as an integral part of PERS to allow convenient and timely post processing (filter, unit conversion, synchronization, graph, display, export, etc.) of the data.

PHASE I: Develop a plan to design a PERS (hardware, software, and instrumentation) into an operational miniaturized system and describe the functional requirements of the various sub-systems. The contractor has significant flexibility in system design to meet the desired objectives. A minimum of three innovative approaches (conceptual designs) should be explored, and a working prototype fabricated of the most feasible design. In this phase, the contractor will demonstrate the concept feasibility by fabricating a prototype that can record 6 head impact acceleration signals, 3 head/torso posture angles, and 6 physiological EMG signals. Minimum sampling rates of 100 Hertz per channel are required for all signals except for head impact accelerations, which require as much as 10 kHz per channel. The PERS should allow continuous data acquisitions for up to 4 hours for all signals, except head impacts, which shall be acquired at the higher rate in short bursts of 250 ms, and allows storage of many such bursts. Calibration, diagnostic and data downloading and post processing procedures shall be demonstrated in the prototype. At the end of Phase I, the prototype shall be delivered to the Army for further testing and evaluation.

PHASE II: Based on critical review of the design and performance of the Phase I PERS prototype, refine its capabilities to resolve identified technical problems. Miniaturize the PERS design into a system that is safe and non-interfering with the soldier's movements, reliable and easy to operate, and has sufficient design flexibility to allow the user to accommodate different mission scenarios by selecting the appropriate data acquisition configurations. A minimum of three PERS units shall be fabricated for testing and field demonstrations. All three systems shall be able to operate simultaneously in close proximity. At the end of this phase, two of the PERS prototype units shall be delivered. A final report on the PERS design and operating instructions shall also be delivered at the end of Phase II.

PHASE III DUAL-USE APPLICATION: A safe, lightweight, man-mounted recording system with appropriate sensors would allow the testing and evaluation of human exposure and tolerance in the area of musculo- skeletal fatigue and injury. Medical personnel concerned with biomechanical stress (e.g., orthopedists, physical medicine and occupational medicine specialists, sport medicine, etc.) routinely seek to quantify physical stress in the workplace. If properly miniaturized and fabricated this device would be a non-intrusive method of gathering occupational health and safety data for symptomatic individuals as well as studying whole occupations in a research setting. Professionals from a wide variety of backgrounds who require monitoring of relative motions of various parts of the human body will find the PERS extremely useful. KEY WORDS: data acquisition, signal processing, telemetry, sensors, physiology, biomechanics, mechanical shock, whiplash, repetitive motion syndrome, neck fatigue, musculoskeletal disorders, head injury.

REFERENCES: Bernard, B.P. (Ed.) 1997. Musculoskeletal disorders and workplace factors: A critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremities, and low back. NIOSH Publication No. 97-141. Cincinnati, OH.

A99-065 TITLE: Systems for Improved Manufacture of Human Fibrinogen

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Development of recombinant human fibrinogen

DESCRIPTION: 50% of KIA's and 25% of DOW's die from uncontrolled hemorrhage. These statistics have not changed for over 100 years. Recent developments have suggested that a fibrinogen based hemostatic bandage can reduce blood loss in severe traumatic and life-threatening hemorrhage and can improve survival. Presently, the cost of fibrinogen makes these bandages extremely expensive and precludes wide spread use and easy replacement as envisioned for local hemostatic agents in combat. The low yield of fibrinogen via present methods (Cohn fractionation) drives the cost. A less expensive manufacturing process would reduce the cost of fibrinogen and make field use of a fibrinogen-based local hemostatic agent feasible. Recombinant methodology would reduce concerns of contamination with blood borne pathogens.

PHASE I: Demonstrate cloning of intact DNA for the three subunits (a, b, and g) of human fibrinogen. Identify vector(s) for optimal transfection of human fibrinogen. Identify cell line(s) for optimal production of functional fibrinogen. Demonstrate chemical and functional equivalence of plasma-derived and recombinant human fibrinogen. Define optimal storage conditions for recombinant human fibrinogen. Perform or participate in preclinical testing of recombinant human fibrinogen to include in vitro testing of clot strength and standard clotting tests.

PHASE II: Define a large-scale process for developing recombinant human fibrinogen. Demonstrate longevity of recombinant human fibrinogen through long term storage studies. Introduce recombinant human fibrinogen to present formulations of fibrinogen-based local adhesive bandages. Perform or participate in 1) preclinical testing of the recombinant

human fibrinogen-based local adhesive bandage to include in vivo testing using existing animal models and 2) clinical testing. Candidate products must be tested against the fibrinogen (plasma-derived)-based bandages.

PHASE III: Produce and support recombinant human fibrinogen during its introduction into clinical use.

COMMERCIAL POTENTIAL: Significant worldwide commercial potential provided large scale manufacturing cost is lower than present procedures.

KEYWORDS: hemostasis, trauma, adhesive bandage, fibrinogen, recombinant

A99-066      TITLE: Attractant/Insecticide Combination to Eliminate Transmission of Tick- and Chigger-borne Diseases

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Formulate a product which can be sprayed on vegetation or the ground to attract ticks and chiggers to a toxicant, effectively blocking transmission of Lyme disease, ehrlichiosis, scrub typhus, tick borne encephalitis, and other acarine-borne diseases.

DESCRIPTION: Tick and chigger-borne diseases are major threats to deployed and training troops in many parts of the world. In the U.S., ticks are responsible for transmission of Lyme disease, two kinds of ehrlichiosis, and Rocky Mountain spotted fever -- any of which can be fatal or debilitating. Overseas, ticks transmit many kinds of spotted fevers and encephalitis-producing viruses, as well as the diseases in the U.S. Chiggers transmit scrub typhus in Asia, a disease which was a major hindrance to our forces in World War II and Vietnam. Current tick control involves area-wide application of insecticides such as chlorpyrifos which, although legal, are highly toxic and must be used in relatively large quantities. Chiggers are difficult to control with any insecticide, partly because they can remain hidden in the soil. Although no commercial product is available to attract ticks and chiggers, there is abundant evidence that such chemicals exist. Specifically, the secretions of skin glands in deer are highly attractive to ticks and adult chiggers are attracted to their prey, insect eggs. This project would involve the combination of very small quantities of insecticide in a spray or granule which contains chemicals highly attractive to ticks and chiggers. Because the ticks and chiggers would actively seek the formulation, very little toxic insecticide would be necessary to achieve effective control. The spray or granule would have to be formulated to last at least two weeks in the field, eliminating ticks and chiggers from the areas around encampments or along roadsides. Low toxicity would allow the use of the material in environmentally sensitive areas and where there might be much human activity.

PHASE I: Produce a trial formulation that attracts at least one species of tick or chigger to a toxic compound in the laboratory.

PHASE II: Expand tests of effectiveness of formulation to major species of vector ticks and chiggers world-wide, using laboratory tests where appropriate. Perform at least three field trials, showing effectiveness against at least two species of ticks and one species of chigger. Develop data for EPA registration.

PHASE III: The product from this project would have great potential for dual use application. Ticks are responsible for the greatest number of arthropod-borne diseases in the U.S. An effective, environmentally friendly, and safe product for tick and chigger control could be used by literally millions of customers in the U.S. and abroad for control of ticks transmitting Lyme disease, ehrlichiosis, and spotted fevers -- all diseases of major public concern. The environmental safety of such a product would make it suitable for use in national parks, near ponds, and in other sensitive areas where people often encounter ticks and chiggers.

KEYWORDS: tick, chigger, insecticide, attractant, disease, force multiplier

A99-067      TITLE: Biological Agent Sample Preparation for the Detection and Identification of Multiple Agents by Nucleic Acid-based Analysis

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop a rapid and relatively simple method(s) for preparing nucleic acid from threat agents of biological origin (anthrax, plague, Brucella, Clostridium, Venezuelan equine encephalitis virus, and more) and endemic infectious diseases (malaria, enteric disease, dengue viruses, hantaviruses, Filoviruses and more) with either DNA or RNA genomes from clinical samples including blood, or swabs of potentially contaminated areas. Procedures that minimize labor-intensive steps, maximize automation and interface with portable, integrated detection devices will be given the highest priority.

DESCRIPTION: Modern molecular biology techniques are able to rapidly and accurately detect and identify negligible amounts of pathogen nucleic acid. In vitro amplification procedures such as polymerase chain reaction, are able to detect fewer than 100 copies of agent and can distinguish single base pair differences. This technology could be a powerful weapon against endemic infectious disease agents and biological warfare agents that threaten troop readiness. However, full implementation and benefit of this technology is hindered by sample preparation procedures. Current sample preparation procedures often employ hazardous materials that require special handling and disposal, and are labor-intensive, requiring many hands-on manipulations that overtime degrade the performance of the assays. This problem is further exacerbated by the variety of agents and sample matrices encountered. Agents can have either DNA or RNA genomes; can exist in different forms, e.g., spore versus vegetative cells; and can be found in sample matrices such as clinical specimens including blood, urine, or saliva; or such as swabs of potentially contaminated areas. The Department of Defense field medical laboratories and counter terrorist response teams need new procedures to rapidly and simply prepare samples for nucleic acid based detection assays. This technology should be compatible with the Department of Defense's goal of developing a portable, integrated nucleic acid detection system.

PHASE I: Initial studies should focus on adapting government requirements to currently working sample preparation procedures. Commercial partner would work closely with government scientists to test procedures and instrument design. Proposed technologies should be able to prepare samples for testing 3-5 biological agents to include at least one agent with an RNA genome in addition to agents with DNA genomes. Preference will be given to procedures that employ a single technology to prepare both types of nucleic acid. Integration of the sample preparation procedure into an amplification/detection system is desirable. Technologies other than PCR are encouraged. Sample preparation technology should be capable of miniaturization. Approaches will be evaluated for sensitivity, specificity, ruggedness, and ease of use. The government will supply information and selected reagents as appropriate for a demonstration of proof of concept.

PHASE II: After demonstration of a proof of concept in Phase I, the commercial partner would optimize procedures to prepare nucleic acid from samples for testing for 10 different biological agents (TBD) and construct prototype devices for field testing at government facilities.

PHASE III DUAL USE APPLICATIONS: At least 5 working devices to test the 10 different agents would be required as a final deliverable after a performance review of prototype devices. The commercial partner would lead the design and assembly of the system into fieldable kits based upon established government protocols. Reagents, preferably in lyophilized form, must be stable for at least 1 year at ambient temperatures. Kits for at least 1000 specimens will be included as a final deliverable. There are universal applications for the proposed technology. Sample preparation is a major stumbling block to the full implementation of gene amplification technology. Estimated size of the commercial diagnostic device market in the United States is over \$5 billion per year. The ability to prepare DNA and RNA for in vitro amplification by a simple, rapid procedure will greatly facilitate the utilization of this technology and increase its benefits. A simplified, sample preparation procedure for both DNA and RNA would be broadly accepted by the research and diagnostic community currently using PCR and other gene amplification procedures.

KEYWORDS: diagnostic assays, nucleic acid amplification, fieldable devices

A99-068 TITLE: Non-invasive Pneumothorax Detection for High-noise Environments

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop a low power, lightweight, hand-held, non-invasive Pneumothorax detector which will allow accurate diagnosis of pneumothorax in environments having high acoustic and electromagnetic noise levels.

DESCRIPTION: A significant fraction of salvageable battlefield casualties die of unrecognized pneumothorax (air in the intra-pleural space) which progresses to cause a tension pneumothorax. This condition compromises cardiac output and oxygenation of the blood. Life-saving treatment is relatively easily implemented by simple introduction of a tube through the chest wall into the air space to allow for relief of the pressure and re-inflation of the lungs. However, diagnosis of this condition is difficult and in fact impossible in high noise environments such as is encountered on the battlefield or even in the back of civilian ambulances. Such a device would assist medics in the early diagnosis of this condition and would save lives.

PHASE I: Identify a methodology for accurately (down to 50 ml) detecting air in the chest cavity which has the potential for producing a lightweight (less than 1 lb.), low power solution and has a minimal electromagnetic signature. Capability to localize the margins of the air embolus is highly desirable to assist the chest tube placement decision. Build a proof-of-principle prototype to establish the feasibility of the approach using studies of animal models. Explore the potential for the method to be "tuned" to also detect fluid accumulation in the abdominal cavity to expand utility of the device.

PHASE II: Adapt proof-of-principle design to one that considers human factors, ease-of-use, size, power and producability issues. Build a prototype which would qualify for human use and clinical evaluation studies. Demonstrate the



sensitivity and specificity limits in human studies comparing localization and size of the pneumothorax with current standard evaluations.

PHASE III DUAL USE APPLICATIONS: Pneumothorax detection is not only a problem in the military environment but is also a problem in civilian pre-hospital settings. This technology would be a life-saving asset for civilian paramedics and would be of potential monitoring benefit in the hospital setting where pneumothorax is a risk factor in placement of central venous lines.

KEYWORDS: pneumothorax detection, lungs, non-invasive, noise resistant, computer-assisted diagnosis

A99-069

TITLE: Interrogatable Micro-environmental Sensor Pod for Dismounted Infantry

TECHNOLOGY AREAS: Biomedical, Materials/Processes

OBJECTIVE: Design and build an innovative low cost, low power, radio-interrogatable micro-environmental sensor pod and remote receiver system to evaluate ground level environments relevant to dismounted infantry operations in open, wooded, or urban terrain.

DESCRIPTION: There is a continuing need for an easily deployable autonomous environmental monitoring system to support real-time local/small unit infantry operations. In use, a constellation of sensor pods would be "seeded" or deployed across an operational area in advance of, or during, an operation. Depending on scenario, these pods could be considered recoverable or expendable. Because the relevant environment is generally between the ground surface and man height above ground, system packaging must have provision for hasty attachment to a variety of contingency stand-off supports that might include local vegetation or manmade structures. The pod sensor suite will consist of air temperature, humidity, wind speed, wind direction, mean radiant temperature, barometric pressure, rainfall rate, and geo-location. Total weight for an integrated completely weatherproof pod, containing power supply, radio, and sensor suite must not exceed 12 ounces. Radio interrogation ranges will be at least 2 miles, 5 miles, and 10 miles in urban, wooded, and open terrain respectively. Pod power will be sufficient for 72 hours of operation at 15 minute interval interrogation/download rates. The small unit-level command and control remote receiver component will be a hand-held computer with the appropriate radio interfaces and software to interrogate each pod, receive current data, and automatically create a file archive of all time/location-stamped data. These files would be used in producing a variety of onboard weather/terrain related geospatial informational products and predictive model displays relevant to dismounted infantry. Files on the remote receiver system could also be accessible via wireless battlefield Local Area Network (LAN) resources for real-time aggregation and fusion at higher echelon battlefield command and control systems.

PHASE I: Develop overall system design, to include a high level hardware firmware/software requirements document as well as a weight and power requirements budget specification for integrated sensor pod and remote receiver.

PHASE II: Build and demonstrate a working prototype system of eight integrated sensor pods and two base station receivers. Conduct preliminary wind tunnel and field testing to determine overall accuracy/precision of the sensor suite, radio communications range limits, and data loss rates relevant to establishing system feasibility in battlescale scenarios.

PHASE III DUAL USE APPLICATIONS: The system would have significant potential for use in real-time forestry/fire management applications for predicting firefighter heat stress risks and for tracking fire path, and, in civil defense applications, downwind toxic/smoke hazard prediction. In conjunction with a chemical or biological agent detector and appropriate models, the system could provide a complete, rapidly deployable tool for real-time mapping of vapor or particle diffusion/dispersion patterns as well heat injury risks to encapsulated personnel.

KEYWORDS: Environmental sensor suite, weather effects, models, cold stress, heat stress, infantry

A99-070

TITLE: Portable Oxygen Generators

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To develop a lightweight, compact oxygen generator for use in forward medical treatment areas and casualty transport vehicles.

DESCRIPTION: Develop a lightweight electrically powered oxygen generator capable of producing 99% oxygen by concentrating atmospheric oxygen or decomposing water. The oxygen generator will produce oxygen at a pressure of at least 5-psi and a flow rate of at least 3 standard liters per minute (slpm). The oxygen generator may incorporate demand flow control technology but will have to produce at least 3slpm continuously. The oxygen generator could use pressure swing adsorption, ceramic membrane, electrochemical cell, proton exchange membrane electro-chemical cell.

PHASE I: Investigate feasibility and design constraints necessary to initiate developmental work. Fabricate a prototype oxygen generator that produces oxygen continuously at a pressure of 5-psi. The PHASE I prototype may be a sub scale generator that demonstrates the operating principle at a reduced flow rate.

PHASE II: Continue to develop the generator through a series of improved prototypes until a full performance prototype is ready for Food and Drug Administration approval.

PHASE III DUAL-USE APPLICATIONS: The oxygen generator would be directly applicable to the home oxygen therapy market. Currently this market sells over 100,000 oxygen generators per year.

KEYWORDS: oxygen generators, medical devices, electro-chemistry, ceramics, zeolite

A99-071

TITLE: Systems for Improved Homeostasis

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Improve hemostasis with fibrinogen-free local hemostatic bandage.

DESCRIPTION: 50% of KIA's and 25% of DOW's die from uncontrolled hemorrhage. These statistics have not changed for over 100 years. Local adhesive agents fall into two classes: 1) liquid sealants or glues and 2) bandage type sealants. Only the bandage formulations are appropriate for massive trauma. Recent developments have suggested that a fibrinogen based hemostatic bandage can reduce blood loss in severe traumatic and life-threatening hemorrhage and can improve survival. Presently, the cost of fibrinogen makes these bandages extremely expensive and precludes wide spread use and easy replacement as envisioned for local hemostatic agents in combat. A less expensive bandage, as effective as fibrinogen formulations, would make field use of a local hemostatic agent feasible.

PHASE I: Identify the fundamental components critical for an effective local hemostatic bandage. Identify those agents (cryoprotectants, drying agents), acceptable for human use, to be used in the stabilization of the bandage during processing. Define storage conditions not requiring processing of bandage before use.

PHASE II: Define a large-scale process for developing the bandage. Demonstrate longevity of bandage through long term storage studies. Perform or participate in 1) preclinical testing of the bandage to include in vitro testing of clot strength and in vivo testing using existing animal models and 2) clinical testing. Candidate products must be tested against the fibrinogen-based bandages.

PHASE III: Produce and support such a bandage during its introduction into clinical use.

COMMERCIAL POTENTIAL: Significant worldwide commercial potential provided product demonstrates efficacy in microvascular and severe traumatic hemorrhage.

KEYWORDS: hemostasis, trauma, adhesive bandage

A99-072

TITLE: Development of novel procedures for determination of Immunologic Consequences of Repeated exposures of Homologous Cholinesterases in Nonhuman Primates

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Cholinesterases have been proven to be effective bioscavengers of toxic organophosphates in animals. However, when butyrylcholinesterase from another species (heterologous enzyme) is repeatedly injected into animals, antibodies against the enzymes are elicited. Although these antibodies cause no behavioral consequences, in response to repeated injections of butyrylcholinesterase, the concentration of antibodies gradually increases, neutralizing subsequently administered free enzyme. Such neutralization of free butyrylcholinesterase in circulation negates its properties as a bioscavenger for toxic organophosphates. This immunological response has not been tested with homologous cholinesterases, i.e., with enzyme from the same species. If human butyrylcholinesterase is to be used in battlefield conditions as a prophylactic treatment drug for nerve gas exposure to soldiers, and if the expectation is that the protective enzyme would be used more than once in a soldier, then knowledge of the immunologic consequences, or the lack thereof, is essential. The objective of this proposal is to devise novel ways to test the administration and immunoreactivity of serum butyrylcholinesterase isolated and purified from nonhuman primates and administered to the same species. Proof of the safety and efficacy of a biological product derived from human plasma is required before the biological product can be employed as a treatment drug or vaccine. One of the newer approaches to this proof, which is approved by the FDA, is the testing of such a biological product in nonhuman primates. Results obtained from these studies can be extrapolated for human IND studies in the FDA preproposal process for the use of human serum butyrylcholinesterase in humans as a pretreatment or treatment drug for chemical agent exposure.

DESCRIPTION: Butyrylcholinesterase present in the serum or plasma of nonhuman primates will be collected, isolated, and enriched. When adequate amounts of enzyme have been obtained, animals of the same species will be repeatedly exposed to the enzyme by means that mimic its use in battlefield conditions. Response to repeated exposures will be monitored by devising novel methods to assess circulating levels of free enzyme and anticholinesterase antibodies.

PHASE I: (1) Collect plasma from nonhuman primates. (2) Isolate and enrich butyrylcholinesterase. (3) Expose animals to butyrylcholinesterase and devise methods to monitor appearance in circulation of free enzyme and anticholinesterase antibodies.

PHASE II: Continue (1) collection of plasma and (2) isolation and enrichment of butyrylcholinesterase. (3) Repeat exposures with monitoring of free enzyme and antibody response.

PHASE III DUAL USE APPLICATIONS: Demonstration that single or repeated injection of homologous cholinesterases had no immunological consequences would provide initial data leading to a pretreatment agent not only for soldiers but for any other first responders (civilians) to terrorist nerve gas release/attack or pesticide overexposure. It will also provide treatment for cocaine overdose. Prior to IND studies, the FDA requires that a biological product be tested for lack of immunoreactivity in nonhuman primates. Therefore a need exists to study in monkeys or chimpanzees the immunologic response of repeated injections of homologous butyrylcholinesterase. The data derived from such a study can be submitted as a prerequisite to IND Phase I studies in humans with human butyrylcholinesterase as a bioscavenger for organophosphates. The study will allow development of techniques for pre-IND testing of drugs in primates as well as producing blood products for commercialization. Products arising from this project are (1) development of a procedure which can be used for testing biological products in pre-IND studies, i.e., vaccines, neuroactive enzymes, recombinant proteins, other macromolecules, (2) experience in and guidelines for setting up such studies, and (3) blood products, which have potential commercial value as useful reagents and test materials. Note: We know of at least three small businesses that have the facilities and resources to pursue such a study and are interested in submitting proposals.

KEYWORDS: Cholinesterases, nonhuman primates, anticholinesterase antibodies, chemical agents, pesticides, cocaine.

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A99-073 **CANCELLED**

A99-074 TITLE: Non-intrusive Lactate Sensor

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To develop a light-weight, rugged, non-invasive sensor which could be worn or applied to the skin to detect tissue serum lactate concentration.

DESCRIPTION: To enable the combat medic to accurately assess the physiological status of an injured soldier, light-weight, rugged, and non-invasive physiological sensors are needed which can be used to continuously monitor the soldier's medical status. Determining which patients require fluid resuscitation based upon metabolic status of the casualty would improve the combat medic's ability to differentiate soldiers with significant blood loss, from those with minimal metabolic derangement. Currently, serum lactate is utilized in the hospital environment to evaluate the not only the effectiveness of resuscitation from hemorrhagic shock, but the level of metabolic derangement secondary to acute blood loss. Recent studies have indicated that serum lactate may be the best indicator not only severity of circulatory shock states, but also of the adequate restoration of intravascular volume status. However, current technology precludes measurement of lactate except by removing a sample of blood, which currently limits this parameter to the hospital setting. This proposal requires the development of a sensor to be used in a non-invasive fashion to measure tissue blood lactate concentration.

PHASE I: Develop system design and demonstrate ability of the sensor to non-invasively measure lactate in relevant physiological ranges of normal and shock states.

PHASE II: Develop and demonstrate a prototype sensor in a realistic environment. Conduct testing to prove accuracy during shock states.

PHASE III: POTENTIAL COMMERCIAL MARKET: This sensor could be used in civilian emergency and critical care medicine to monitor tissue perfusion, severity of shock states, and level of resuscitation.

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KEYWORDS: sensors, biomedical device, lactate, non-invasive, shock, resuscitation, injury

A99-075      TITLE: Blast Mitigation Jacket for Training

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop a lightweight jacket that modifies the impulsive noise loading to the thorax so that nonauditory effects can be mitigated.

DESCRIPTION: Soldier training using certain large caliber weapons, shoulder-fired anti-material weapons, and weapons fired from enclosures exceed tolerances for nonauditory injury, in particular injury to the lung from rapid chest wall motion. When these limits are exceeded, occupational safety considerations require that training be restricted or prohibited. Although this is a valid occupational concern, these limitations in training decrease the soldier's effectiveness in actual combat deployment and, therefore, could be detrimental overall. Considerable research has been conducted to determine the biomechanical origin of this injury and some studies have shown that certain aspects of clothing, especially the effects of trapped air and areal mass density, can modify the loading seen by the body and therefore modify the biomechanical response. Other studies have shown that increasing the duration of loading, even if total impulse is not changed, can dramatically reduce traumatic body response.

PHASE I: Demonstrate the feasibility of using clothing materials, combined with control of air spaces, to alter the thoracic loading and to reduce the anticipated nonauditory hazard. Use the prototype tests to estimate the amount of protection in terms of jacket weight and bulk.

PHASE II: Refine and improve promising design concepts. Work with Army materiel developers to identify ways to incorporate these blast mitigation features into standard training clothing, if possible. Demonstrate the increased protection using actual jackets and anthropomorphic dummies.

PHASE III DUAL USE APPLICATIONS: The modification of impulsive loading to the body and subsequent reduction of trauma is a component of the design of ballistic garments worn by law enforcement and by bomb disposal personnel.

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KEYWORDS: blast injury, explosives, protective clothing, soldier training

A99-076      TITLE: Non-invasive, Lightweight Cardiac Output Detection for Use in the Battlefield and High Noise Environments

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Develop a low power, lightweight, hand-held, non-invasive cardiac output measurement device which will allow accurate continuous measurement in environments having high acoustic and electromagnetic noise levels

**DESCRIPTION:** Cardiac output measurement in the hospital setting is currently accomplished by both invasive and non-invasive techniques, however, invasive techniques remain the most reliable standard. Although non-invasive cardiac output measurement using thoracic impedance has found some clinical application, the low level electrical signals used in this technique are very susceptible to electromagnetic interference and motion artifact. Unfortunately, these conditions are commonly encountered in the environments of military field medicine as well as in civilian pre-hospital emergency medical systems. Determination of cardiac output and blood pressure non-invasively and continuously, would give an excellent characterization of the cardiovascular system and would have great value in the management of shock and trauma as well as monitoring soldier physical performance parameters for operational medicine applications.

**PHASE I:** Identify a methodology suitable for accurately measuring cardiac output non-invasively over the range of 1 to 20 L/min which has the potential for producing a lightweight (less than 1 lb.), low power solution having a minimal electromagnetic emission signature and low susceptibility to electromagnetic environments. Focus on resistance to motion artifact is also important. Two design configurations are desired, one for ambulatory monitoring and one for hand-held use by a medical caregiver. Build a proof-of-principle prototype to establish the feasibility of the approach using studies of large animals and/or humans.

**PHASE II:** Adapt proof-of-principle design to one that considers human factors, ease-of-use, size, power and producibility issues. Build and deliver a prototype which would qualify for human use and clinical evaluation studies. Demonstrate the sensitivity and accuracy in human studies comparing the technique with accepted methods of cardiac output measurement.

**PHASE III DUAL USE APPLICATIONS:** A non-invasive, continuous means of assessing cardiac output would find ready application in both the military and civilian acute trauma care settings. Ambulatory monitoring is needed in the military for soldier performance and readiness evaluations and in the civilian home medical care environment for possibly post-operative follow-up or chronic care of the elderly or chronic cardiac cardiovascular

**KEYWORDS:** pneumothorax detection, lungs, non-invasive, noise resistant, computer-assisted diagnosis

A99-077                      **TITLE:** Stabilization of Critical Reagents

**TECHNOLOGY AREAS:** Biomedical

**OBJECTIVE:** To demonstrate technology for stabilization of reagents used in diagnostic assays at or above ambient temperature.

**DESCRIPTION:** Multiple types of reagents are used in carrying out diagnostic assays. Currently, the long-term stability of these reagents is limited at temperatures above -20 C. Traditional methods of stabilization such as lyophilization offer improvements but may not meet future military requirements. Department of Defense field medical laboratories and counter terrorist response teams use diagnostic assays capable of detecting and identifying a wide array of biological threats. Deployment of these laboratory assets often exposes equipment and reagents to environmental extremes include high temperature and humidity. Because these laboratory assets may be located in inhospitable and remote locations, electrical power may be unreliable or non-existent. Therefore, it is essential that methods for the stabilization of critical reagents be developed such that refrigeration is not required. To meet the demands for reagent stability, a method or methods for preservation must be developed to maintain the specific activity of reagents at or above ambient temperature for one year. Reagents of interest include protein antigens, antibodies, other protein ligands, genomic length nucleic acids (both RNA and DNA), oligonucleotides, enzymes, and enzyme substrates. Procedures for stabilizing reagents in single and multiple use containers and in multi-well plates and reaction tubes should be developed. Technologies that reduce the effort and time associated with reagent reconstitution will be given the highest priority. All technologies being considered must interface seamlessly with standard assay protocols and formats including ELISA and PCR.

**PHASE I:** Initial studies should focus on the development of a process for stabilizing reagents using prototype technologies. Commercial partners would work closely with government scientists to choose reagents and assay formats for evaluation and for the testing of the final products. Proposed technologies should be able to stabilize reagents of interest at 25-30 C with no loss in activity for up to one year. Accelerated stability testing data are sufficient for this stage of work. A loss in activity will be detected by comparing the activity of reagents stabilized using traditional procedures (lyophilization and/or refrigeration) with those stabilized using the technology being tested. The government will supply selected reagents for a demonstration of proof of concept.

**PHASE II:** After demonstration of a proof of concept in Phase I, the commercial partner would optimize stabilization procedures to function with diagnostic reagents necessary to complete eight different diagnostic assays (four immunodiagnostic-based and four nucleic acid-based). Full chemistries and protocols for stabilization of all reagents necessary

for the eight diagnostic assays will be included as a final deliverable after a performance review of phase II data. For evaluation of the stabilization technology under a variety of environmental conditions, the partner will deliver stabilized reagents necessary to complete 500 each of the eight assays in an appropriate format. Phase III: The commercial partner would lead in the large-scale production of stabilized reagents for use by the military or be willing to license the necessary technologies to other interested manufacturers. Stabilization of diagnostic reagents would be of prime concern to all commercial organizations wishing to increase shelf life especially those producing assays for field and environmental use and could lead to important benefits to the commercial partner.

**KEYWORDS:** diagnostic assays, reagent stabilization

#### **Natick Soldier Center (NSC)**

A99-078                      TITLE: Nanotechnology for Ballistic Protection

**TECHNOLOGY AREAS:** Materials/Processes

**OBJECTIVE:** Develop nanocomposite materials to be used in personnel armor for ballistic protection. Utilize emerging nanotechnology to achieve increased protection and/or lighter weight at the same level of protection in small-arms protective vests, plates and helmets.

**DESCRIPTION:** Recent developments in materials research have shown that it is possible to achieve a non-linear enhancement of material properties in composite systems where the size of the phase domains is in the nanometer range. Examples include the numerous reports of small amounts (5-10%) of silicate nanoparticles (such as montmorillonite clays) giving rise to the same level of mechanical properties in polymers as are typically achieved with loadings of 30-50% of micron-sized fillers. Performance enhancement of this type has not been reported yet in the area of ballistic impact resistance. It may be, however, that fully dispersed nanometer scale reinforcing fillers will be able to enhance the energy absorbing capacity and ballistic impact resistance of polymer matrix composites or other composite materials. One proposed mechanism for realizing such performance is the potential of the interphase region of a particle-filled composite to absorb energy. The relative volume of material residing in the interphase zone of a nanocomposite is significantly larger than in composites of larger domain size. It may also be the case that high aspect ratio nanoparticles with anisotropic orientation will assist in distributing the energy of ballistic impact more effectively through a composite material than an isotropic composite with spherical reinforcing particles. Promising nanocomposite materials might be high-impact polymers modified with nanoparticle or nanofiber reinforcement at low levels of loading, or polymer composites highly loaded with hard ceramic particles which might perform the function of current ceramic armor plates but with enhanced toughness and lighter weight. Other nanoscale architectures, such as nanolaminating of materials with varying hardness may give rise to enhanced impact properties. Inducing anisotropic orientation of nanostructural features via processing methods may also be beneficial to impact properties.

**PHASE I:** Identify the most promising nanocomposite material or materials for armor applications. Fabricate flat test panels of the nanocomposite material, suitable for ballistic testing at Natick Soldier Center. The ratio of areal density to level of ballistic protection will be a critical factor in determining the success of Phase I. The new technology should represent significant progress toward the current Army goal for personnel armor of an areal density of 3.5 lb/ft<sup>2</sup> able to defeat all types of 7.62mm bullet threats.

**PHASE II:** Design an armor material system incorporating the new nanocomposite material. Fabricate full-scale samples of this concept armor for ballistic testing. Prepare prototype helmets and/or ballistic protective plates and/or vests using the new armor materials for field testing.

**PHASE III DUAL USE APPLICATIONS:** Law enforcement, security police and armored car personnel are all potential users of lightweight personnel armor.

#### **REFERENCES:**

1. Gonsalves, K.E. et al., Mechanistic investigation of the preparation of polymer/ceramic nanocomposites, NanoStructured Materials, vol. 9, pp. 181-184, 1997. Elsevier.
2. Apte, P. et al., Hardness measurements of nanophase Al/Al-Oxide consolidated components. NanoStructured Materials, vol. 9, pp. 501-504, 1997. Elsevier.
3. Niu, C. and Moy, D., Preparation of silicon carbide nanofibrils from vapor grown carbon nanotubes. Mat. Res.Soc. Symp. Proc. 410, pp. 179-184, 1996.
4. Pinnavaia, T. et al., Clay-reinforced epoxy nanocomposites: Synthesis, Properties and Mechanism of Formation. ACS Symposium Series 622 (Nanotechnology) pp. 251-261, 1996.

**KEYWORDS:** Ballistic protection, armor, bullet resistant, small arms, nanotechnology, composites, nanoparticles, polymers, materials



A99-079

TITLE: Novel Forming Techniques of Complex Shapes in Personnel Armor

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To develop innovative net/near-net shape forming techniques for complex shapes in textile-based personnel armor to improve performance and comfort.

DESCRIPTION: Current manufacturing techniques for textile-based personnel armor focus on constructing complex shapes from orthogonal woven fabrics or flat sheets of nonwoven materials. In order to minimize potential vulnerabilities, cut surfaces are overlapped thus leading to increased weight and reduced comfort. These techniques can also lead to higher cost through added materials handling and material waste. Research and development are required to establish net or near-net shape forming techniques which maintain the ballistic integrity demonstrated by conventional armor systems but minimizes weight, vulnerability and cost. Performance to weight ratios should be maintained or increased (e.g., 9mm/fragmentation protection at 1.0-1.1 lb/sq ft). The approach should be conducive to forming the compound shapes that are required to cover various areas of the body such as the head, breast, shin and arm. Potential approaches may include weaving technology or any other method such as deep drawing processes that would utilize flat materials without introducing overlap to form curved shapes.

PHASE I: Determine the feasibility of the approach to form the complex shapes by fabricating and testing sample panels. Identify potential weaknesses in terms of ballistic vulnerability.

PHASE II: Refine the approach and demonstrate the application of the technology in final configuration through construction and evaluation of item prototypes (e.g., helmet and/or female vest) which are of similar or lighter areal density and provide levels of protection equal or better than the conventionally formed armor systems. Provide final technical report with technical data package.

PHASE III DUAL USE APPLICATIONS: This technology will be directly transferable to the law enforcement body armor industry as well as to other personnel protective applications such as impact resistant helmet. The recreational sports industry would also benefit from near net shape forming methodology.

#### REFERENCES:

1. Bottger, Christian (Akzo Noble Faser AG), Comfortable Bullet-proof Vests for Ladies, Personal Armour Systems Symposium 96 Proceedings, 3-6 September 1996, published July 1996.
2. Lastnik, A.L., A Photo Computer Technique for the Design and Analysis of Personnel Protective Equipment. USNRDEC TR76-2, CEMEL Oct 76
3. Cunniff, Philip M., A Semiempirical Model for the Ballistic Impact Performance of Textile-Based Personnel Armor, Textile Research Journal 66(1), 45-59, 1996

KEYWORDS: Personal armor, ballistic protection, textile technology, net shape weaving, draws forming

#### U.S Army Space and Missile Defense Command (SMDC)

A99-080

TITLE: Common Sense Reasoning to Locate Threats

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Prototype intelligent agent incorporating common sense via a large, multi-contextual knowledge base and inference engine to assist in locating mobile threats soon after detection.

DESCRIPTION: Many warfighters are overwhelmed by the very information they need to master in order to effectively execute their mission. Commanders need state-of-the-art technologies to assist their better understanding and awareness of the battlefield. State-of-the-practice artificial intelligence (AI) methods generally fall short of this goal because they lack the robustness derived from common sense (a basic understanding of physics and the human condition) reasoning. Common sense is required to disambiguate human language, battle situations, information requirements, and battle plans. Unfortunately, common sense is not easily elicited, represented, or automated for reliable human operator performance augmentation. Therefore, a large, multi-contextual knowledge base and inference engine is the ontology for all but the most well bounded problem domains. A knowledge base architecture representation of common sense with associated inferencing capability is required to assist the warfighter in filtering and presenting information about the most likely location and intentions of a mobile threat and associated threat facilities shortly after detection. In addition, the required approach must be flexible and robust enough to cope with emerging battlefield conditions, large quantities of data from disparate sources, missing or corrupt data, and evolving tactics all in real time.

PHASE I: Design and model the most promising method, tool, and/or language containing a large, multi-contextual knowledge base and inference engine for generic common sense and application domain common sense to locate mobile threats and associated facility threats shortly after detection. Demonstrate feasibility of the technology for this application using a simple scenario. The scenario does not have to be military in origin, but must be applicable to the basic problem. Develop a plan for commercial use of the final product.

PHASE II: Develop and test a prototype product that runs in real time on COTS hardware based on the robust intelligent agent proposed in Phase I. Conduct tests to demonstrate military and/or commercial utility and effectiveness in the presence of missing and corrupt data. Demonstrate the commercial utility of the application through simulation and testing. Develop a Phase III commercialization strategy.

PHASE III DUAL-USE APPLICATIONS: Pilots, stockbrokers, design engineers, doctors, lawyers, military commanders, and many other professions now have much more data available to support decisions than can be read or reviewed on a computer. Any AI application that demonstrates common sense in the processing of this information will have many uses in the commercial world.

#### REFERENCES:

1. <http://mitpress.mit.edu/e-books/Hal/chap9.java/nine1.html>
2. <http://www-formal.stanford.edu/jmc/generality/node7.html>
3. <http://sunsite.informatik.rwth-aachen.de/dblp/db/conf/kr/kr96.html#McCarthy96>

KEYWORDS: common sense, artificial intelligence, information processing, knowledge base, inference engine, expert systems

A99-081                      TITLE: Mitigation of Magnetohydrodynamic Electromagnetic Pulse Effects on Long Lines for Missile Defense System and Infrastructure Protection

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Identify, develop, and demonstrate low-cost techniques to protect military and critical infrastructure systems with long power and communication lines from the effects of MHD-EMP.

DESCRIPTION: Ground based missile defense systems and their supporting infrastructures rely on long line cables for power and communications. Solar geomagnetic storms in northern areas have disrupted equipment on the long lines of protected electrical distribution systems [Reference 1]. The response of nuclear MHD-EMP (E3) is similar to that produced by solar geomagnetic storms, but has somewhat greater electric field intensity [Reference 2] and both can induce very high ground currents that can burnout AC transformers and cause other problems. Because defense systems rely heavily on commercial infrastructure, we propose to develop low-cost, widely-applicable mitigation technologies to alleviate the effects of MHD-EMP on military systems and their supporting infrastructure. Mitigation will require safe and effective dissipation of very large currents and energy. Reference 2 provides an unclassified overview of the MHD-EMP environment.

PHASE I: Analyze, design, and conduct proof-of-principle demonstrations of practical techniques to ensure operability of long-line electrical and communication systems in MHD-EMP environments.

PHASE II: Develop prototype protection devices and conduct tests to evaluate the performance of protection devices and protected equipment in MHD-EMP environments. Prepare detailed plans to implement demonstrated capabilities on critical military and commercial applications.

PHASE III DUAL APPLICATIONS: Dual applications exist for MHD-EMP mitigation technologies within the commercial electrical power distribution industry. Commercial power distributors must ensure that critical electrical systems remain operable in the presence of solar geomagnetic storms and post-EMP operability is critical to national recovery efforts. While northern power grids have some protection, severe solar storms in the past have still caused widespread disruption. The protection technologies developed by this effort can be applied worldwide to ensure that long-line power and communication systems will not be disrupted by severe geomagnetic disturbances and nuclear MHD-EMP.

#### REFERENCES:

1. What Utilities Learn From Disasters. Electrical World, November 1993, pp. 50-51
2. Barnes, P.R., et al.; MHD-EMP Analysis and Protection. Defense Nuclear Agency Document DNA-TR-92-101; September 1993.

KEYWORDS: MHD-EMP, EMP hardening, geomagnetic storms, survivability

## TECHNOLOGY AREAS: Human Systems

OBJECTIVE: Develop innovative HSI methods and associated device(s) that will combine the human sense of smell with the human sense of hearing to aid human-in-the-loop decision making and analyses of data from disparate sources.

DESCRIPTION: Advances in information systems have made more real-time information available to warfighters. Information must be presented in a manner that will augment the battle commander's decision-making capability, without information overload. A well-designed human-engineered system interface is paramount to minimizing operator decision response times and error rates, to maximizing interaction efficiency and to assuring mission success with advanced weapons systems. Sensory immersion is an emerging science that allows humans to receive and transmit data using all of their senses, i.e., sight, touch, speech, hearing and smell. The objective of sensory immersion research is to improve a human's ability to interact with large amounts of complex data by using more than just sight. Sensory immersion allows a person to interact with data sets the same way they interact with another person. That is through gestures, sound, sight, touch and smell. The objective of the research requested through this SBIR topic is development of HSI methods and associated device(s) that will allow a human to investigate data sets using the sense of hearing combined with the sense of smell. Any proposed research must address both hearing and smell used together to analyze data and support decision making under information overload conditions. Audio cues and audio data have been used effectively to communicate complex data to humans. Olfaction is one of the chemical senses, evolutionarily ancient and capable of recognizing and encoding thousands of different three-dimensional molecular structures with such precision that even molecules that are mirror images of each other can be discriminated. Smell information about our surroundings is acquired, interrupted and stored. Research has shown that odors can be used as stimuli to learning. Odors have also been shown to effect mood and mental alertness. Because of our ability to discriminate between many different odors, odors could also be encoded with information and interpreted directly as data. Device(s) are needed that will take complex data and turn the data into a combination of sounds and smells that can be interpreted by an operator, improving the analyses and decision making capabilities of the operator. The research should also address what types of tasks, under what conditions, are best suited for use of combined auditory and olfactory devices.

PHASE I: Demonstrate the feasibility of constructing and using device(s) that provide data inputs to a human via a combination of sound and smell. Measures of Effectiveness (MOEs) for the HSI methods employed by the device(s) should be defined. Feasibility can be demonstrated through a series of experiments or through simulation, with an emphasis on operator performance (e.g., training time, response time, and number of errors) as measured by defined MOEs. A specific data set addressing specific data to be transmitted should be examined.

PHASE II: Build the device(s) proposed in Phase I and conduct trials of the device(s) to demonstrate the type and amount of information that can be transmitted and understood, with a continued emphasis on analysis and improvement of operator performance.

PHASE III DUAL-USE APPLICATIONS: Humans are faced with huge amounts of data to support their decision-making. Pilots, stockbrokers, design engineers, doctors, lawyers, military commanders, and many other professions now have much more data available to support decisions than can be read or reviewed on a computer. Sensory immersion, using all of the senses to interact with data, can help all of these people make better and quicker decision.

REFERENCES: The following institutes specialize in olfactory research. The Olfactory Research Fund is the world's only non-profit, charitable organization dedicated to supporting research on the psychological benefits of fragrance. The Olfactory Research Fund sponsors numerous research topics each year and has a catalog of published papers.

1. California Institute of Technology Engineering Research Center, Neuromorphic Systems Engineering, <http://www.erc.caltech.edu/index2.html>
2. The Olfactory Research Fund, Ltd., 145 East 32nd St., New York, NY 10016-6002, <http://www.olfactory.org/news.html>  
The following University websites contain information on auditory perception research.
3. McGill University, <http://www.music.mcgill.ca/auditory/intro.html> Auditory Mechanics Lab, <http://funsan.biomed.mcgill.ca/>
4. University of California Berkeley, Department of Psychology, <http://ear.berkeley.edu/> Auditory Perception Lab, [http://ear.berkeley.edu/auditory\\_lab/](http://ear.berkeley.edu/auditory_lab/)

KEYWORDS: sensory immersion, human computer interface, multi-sensory interfaces, olfaction, audio cues, auditory/olfactory devices, decision support

A99-083

TITLE: High-energy Laser Optical and Diagnostic Development

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: To create advanced innovative optical materials, technologies, fabrication methods, and equipment, thereby improving the performance of DOD High Energy Lasers and develop new optical and diagnostic technologies.

DESCRIPTION: We at the High Energy Laser Systems Test Facility (HELSTF) propose the creation of specialty optics, sensors, and equipment for use in testing with HF/DF chemical High Energy Lasers (HELs), Free Electron Lasers (FELs) as well as pulsed CO2 HELs. Of specific interest are materials that act as high power frequency converters. Additional specific interests include the use of uncooled reflective optics and beam splitters for extracting low(er) power samples of a HEL beam for a beam diagnostic station or for auxiliary experiments. Advanced polishing and fabrication techniques able to create surface finishes of few (<10) angstroms are also very suitable to this proposal topic as are advanced laser diagnostics which have both low and high power applications. The explicit keys here are innovation, usefulness with high energy laser facilities, and commercial application potential.

PHASE I: Proposers should plan on early experimentation to demonstrate proof of principle for their innovative ideas. A detailed effort to further analyze the new technology proposed will be required as will design for full scale Phase II hardware. Ability to attract Phase III commercial partners for funding is highly regarded.

PHASE II: Second Phase efforts will include innovative developments, hardware fabrication, and demonstration using Army lasers and equipment. Publication of results at all phases is encouraged to attract follow-on interest.

PHASE III DUAL USE COMMERCIALIZATION: The market for specialty optical equipment is very large for several different end use applications. Commercial and civil uses of high energy lasers such as laser welding, laser machining, laser surface treatment, laser assisted surface cleaning, laser power beaming, laser assisted mining, military HEL uses, and laser chemical synthesis will all require robust optical and diagnostic developments. Innovative ideas that address both military HEL needs and established or potential commercial applications are appropriate for this topic. Depending on the maturity of the product and market, the commercial potential ranges from a few million to a few billion dollars per year.

KEYWORDS: High Energy Laser Optics, Optics Fabrication, Laser Diagnostics, Specialty Optics, Advanced Optical Materials, Frequency Doubling Techniques.

#### **U.S. Army Simulation, Training, and Instrumentation Command (STRICOM)**

A99-084

TITLE: Distributed Collaborative Java-based Positioning Instrumentation Modules

TECHNOLOGY AREAS: Information System Technology

OBJECTIVE: Develop java-based distributed collaborative Instrumentation modules for tracking dismounted infantry players in a "live" training environment

DESCRIPTION: The problem - Tactical Engagement Simulations (TES) of "live" (ie, actual participants interacting at actual training centers) dismounted infantry engagements need precise soldier positioning information in order to (a) enable the simulation of indirect/area-effect weapons and to (b) enable the generation of high-fidelity after-action reviews (AAR's) using virtual replay mechanisms. The opportunity - leveraging recent advances in embedded java technology, research and develop java-based instrumentation modules that work in a distributed (ie, located on different dismounted infantry participants) collaborative (ie, collective problem solving via exchange of information) manner to more precisely generate positioning information for each of the modules than each module is individually capable of. In other words, apply the principle of sensor array processing --where groups of low-fidelity sensors collectively yield much higher fidelity information.

PHASE I: Develop an overall design concept for providing accurate positions information in the field. Breadboard, demonstrate, or analyze concepts for monitoring.

PHASE II: Build a prototype system which demonstrates the position tracking and its accuracy to meet the training environment. Demonstrate the approach is not intrusive to the individual's mobility.

PHASE III DUAL USE APPLICATIONS: Cost effective solutions could monitor travelers in national recreation areas. Would be effective for monitoring search party/ rescue operations. Security industry could use a low cost position monitoring for site security. Child security for house exit or "entering pool area" notification.

KEYWORDS: positioning information, embedded java, tactical engagement simulation, distributed sensor array processing, collaborative sensors

A99-085

TITLE: Advancements in Individual Combatant Simulation Technology

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: To develop new, innovative and cost effective technological solutions to support immersive simulations for the individual combatant, consistent with the innovative use of entertainment technology and the emerging High Level Architecture (HLA). Uses for the simulations include mission rehearsal, training, analysis and materiel development of soldier systems.

DESCRIPTION: Most of the current virtual environment technologies which support individual combatant virtual simulation suffer from limitations. Some of the key technical challenges in this area include: interoperability, graphics and database complexity, integration into networked simulations, computer generated forces, man-machine interface, individual representation, and instrumentation. There is a current need for technology advancements in the area of voice recognition under stress and gesture recognition to support day / night, open and restricted terrain operations. In addition, there is a need for technology advancements in the area of interaction of Command, Control, Communications, Computer & Intelligence (C4I) systems with IC simulations. Each proposal should clearly identify the area(s) being addressed.

PHASE I: The Phase I effort should focus on developing an overall design concept to (1) integrate voice and/or gesture recognition capabilities or (2) integrate C4I systems to current IC simulations, to include Human-In-The-Loop (HITL) or SemiAutomated Forces (SAF) applications. The product of the Phase I effort should be a technical report and demonstration of the design concept.

PHASE II: The Phase II effort should focus on building a commercial prototype using the results from Phase I. Demonstrate the (1) voice and/or gesture capabilities or (2) C4I system integration with an existing IC simulation using Government approved scenario(s) which include night and day, open and restricted terrain operations.

PHASE III DUAL USE APPLICATIONS: The proposed developments would have application in many commercial markets, including entertainment, communications, and instrumentation. Potential commercial simulation system applications include video games, virtual reality systems, and non-military training systems such as firefighter and emergency management trainers.

#### REFERENCES:

1. The following web site address may be helpful in providing relevant background information for IC simulation development: [www.stricom.army.mil/PRODUCTS/DWN](http://www.stricom.army.mil/PRODUCTS/DWN).
2. Jones, T (1995) Individual Combatant Simulation Technology Transfer Plan.

KEYWORDS: individual combatant, dismounted infantry, computer generated forces, military operations in Urban terrain

### **U.S. Army Tank, Automotive, and Armament Research Development and Engineering Center (TARDEC)**

A99-086

TITLE: Compression Ignition Engine Technology Insertion

TECHNOLOGY AREAS: Ground and Sea Vehicles, Materials/Processes

OBJECTIVE: Perform feasibility research on and demonstrate potential for advanced technologies, suitable for insertion in compression ignition engines (e.g., up to and including class 8 truck engines) to improve engine performance and assure greater conformity with future system's technologies. Technologies that can more readily be inserted (i.e., improved/intelligent engine controls and/or associated enabling sensor technologies, parasitic load reduction technologies such as might be accomplished through functional integration or elimination approaches (e.g., combined starter alternator) and improved combustion concepts (e.g., stratified combustion approaches) are examples of desired research topics. Proposals that include research collaborations with current engine manufacturers will demonstrate the level of program commitment desired.

DESCRIPTION: Optimal applications of new advanced engine technologies often require alternative (e.g., new) systems' configurations. However, failure to research, develop and apply these new technologies on existing equipment may create future logistics and cost burdens (i.e., dual fuel delivery systems for current and future engines, incompatibilities in lubrication or electrical control systems, etc.). Significant research and development must be performed to address design, both performance and durability, issues related to inserting advanced technologies into engines developed in the 70's and 80's. These legacy engines in the existing military fleet will be maintained in inventory beyond the year 2010 due to budgetary constraints on new systems developments and acquisitions. In contrast, rapid global technology advancements and foreign military R&D

investments / hardware acquisitions heighten military needs and threaten U.S. superiority on the future battlefield. Army R&D initiatives, therefore, must research advanced technologies' application potential for improving functional performance of existing equipment during retrograde, while retaining engine systems configurations compatibility (i.e., technology insertion through form and subsystem/component interface).

PHASE I: The contractor shall research specific advanced compression ignition engine technologies as specified in the proposal and develop concepts for integration in existing diesel engine designs. The contractor shall identify and verify technology integration benefits and design issues. The contractor shall perform virtual prototyping and simulation modeling of modified engine design concepts that could be realized through an engine technology insertion program for a specified combined military- & commercial-use engine (e.g., up to and including class 8 truck engines). Technology insertion research/development design plan and cost savings analysis shall be prepared to document optimal technology integration design configuration, performance verification test procedures and expected benefits. In addition to developing preliminary engineering designs for one agreed upon engine, the contractor shall model and evaluate virtual prototype manufacturing processes required to implement the recommended engine technology insertion. Proposals that offer to supply commercial products for government evaluation do not qualify as innovative research and development.

PHASE II: Actual prototype engine modification (e.g., technology insertion) shall be performed in cooperation with the Army overhaul agent (e.g., contractor or depot), manufacturing procedures verified and engine performance tests performed.

PHASE III DUAL USE APPLICATIONS: Commercial bus and truck fleets accumulate significantly greater mileage and undergo more frequent engine rebuild cycles than military ground vehicle power plants. An Army proactive research program would promote commercial engine material adoption by lowering technology insertion risks, providing increased fleet usage data, and defining re-manufacturing procedures/competencies.

OPERATING AND SUPPORT COST REDUCTION (OSCR): The Army has thousands of commercially based engines installed in military vehicles, which will be maintained in inventory beyond the year 2010. Remanufacture programs for these engines will be conducted on a regular, as required, basis. The OEM manufacturer typically guarantees availability of engine parts for 10 years after cessation of production, but component acquisition costs increase 10% to 15% per year due to the lack of a commercial market demand. By initiating the proposed technology insertion effort, the Army can reduce dependence on obsolete commercial components and increase use of state-of-the-art commercial parts and technology, while extending component/system life and improving vehicle performance in three critical areas, fuel economy, noise and exhaust emissions.

KEYWORDS: diesel engine advanced technologies, technology insertion, diesel engine re-manufacture, compression ignition engine technologies

A99-087

TITLE: Smart Lead Acid Batteries for Starting, Lighting, and Ignition Applications

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The objective of this project is to develop an existing cost-effective smart battery electronic controller for use in lead acid batteries in automotive vehicles.

DESCRIPTION: Smart batteries are presently used and widely found in laptop computers. The initial capital investment has been made to bring the component cost to the level favorable for making a smart automotive battery a reality. We wish to modify this controller component to (1) operate with lead acid batteries in automotive applications, (2) communicate with existing or proposed vehicle data bus networks, (3) store and report on demand historical battery usage data, (4) ensure adequate component survivability in the corrosive battery environment and (5) ensure conformance with established military requirements. This could include the development of a programmable flash memory capability. This would allow changes to be made as needed to meet the evolving smart system requirements of existing and future combat and tactical vehicles. This program is an important step for improving an essential vehicle component (i.e., the battery) to provide health and status information to a smart vehicle system by way of a vehicle system data bus. The advantages for having this kind of control over the batteries extend to longer life batteries and improved vehicle system readiness.

PHASE I: Develop overall component design and specification. Provide for and propose a digital communication protocol for this component. Develop a plan for integrating the component into existing lead acid batteries for automotive application.

PHASE II: Build ASIC chips and electronic support sub-structure incorporating the best design capable of meeting the above-mentioned description. Demonstrate performance in prototype batteries. Incorporate the smart controller into a lead acid battery as an integrated component permitting access to the connector for external monitoring.

PHASE III DUAL USE APPLICATIONS: This program applies to commercial as well as the military vehicle applications. Specifically, there presently exists an identified need for this same smart battery capability in trucks for long distance freight service.

REFERENCES: "Smart Batteries, North America Sales Forecasts, Demand Characteristics, Competition and Technology Trends," The Darnell Group, Norco, California, 1995.

KEYWORDS: smart batteries, lead acid batteries, smart systems

A99-088                      TITLE: Advanced Opposed-piston 2-stroke Diesel Demonstrator

TECHNOLOGY AREAS: Ground and Sea Vehicles, Materials/Processes

OBJECTIVE: The objective of this topic is to develop an advanced opposed piston 2 stroke diesel research engine able to serve as a demonstrator for advanced technologies including scavenging, fuel injection and combustion, and low heat rejection technology.

DESCRIPTION: The opposed piston 2 stroke format has unique characteristics making it exceptionally well suited for combat vehicle propulsion. The application of advanced technologies to this format has not kept pace with the 4 stroke engine community however, due to the specialized nature of this design. An advanced opposed piston 2 stroke diesel research engine is needed to serve as a technology test bed to demonstrate the full potential of this design for future vehicle programs. The single cylinder research engine envisioned under this topic should provide flexibility to pursue innovative scavenging, fuel injection, combustion and insulative concepts. Access for extensive instrumentation including pressure transducers, thermocouples and gas sampling probes should be provided. The engine should make use of commercially available parts to the greatest possible extent to reduce operating costs. Cylinder displacement is expected to be on the order of 2.5 - 3.0 liters per cylinder to provide 250 hp rated output per cylinder at 2600 rpm.

PHASE I: The contractor shall perform a design study and make detailed drawings for all major engine components.

PHASE II: The contractor shall fabricate the engine and perform operational testing.

PHASE III DUAL USE APPLICATIONS: 2 Stroke diesel engines have found applications ranging from trucks & bus power to large marine and stationary plants. While not all of these are of opposed piston format they will benefit from the development of advanced technology for the 2 stroke engine.

KEYWORDS: opposed piston, 2 stroke, diesel engine

A99-089                      TITLE: Surfactant Resistant Fuel Filtration

TECHNOLOGY AREAS: Ground and Sea Vehicles, Materials/Processes

OBJECTIVE: Demonstrate technical feasibility of advanced filtration and water removal technologies that are resistant to disarming by the presence of strong surfactants in fuels, such as JP8+100. Initial investigation will focus on track and wheeled vehicle applications.

DESCRIPTION: Development of advanced engines for use in future military systems, particularly aircraft, are requiring fuels with greater thermal stability. Fuel additive packages that increase thermal stability typically include a strong detergent/dispersant that disarms conventional coalescing elements used to remove undissolved water from the fuel. The technology and process used in the conventional military and commercial fuel filter-separators is well over 30 years old. In terms of operation, the current systems are simple and require no power source of their own, relying on the pumping pressure of the system to push fuel through the filters. In terms of supply, the filter/coalescing elements become clogged and must be replaced periodically, which requires an available resupply in the field, an added logistics expense. It would be desirable for the military, and certainly the commercial sector, if fuel filtration could enter the 21st century with an improved technology. Possible improvements include regenerative filters which are either non-replaceable or offer extended service intervals, or are field cleanable and reusable. The performance of the filters should at least meet API (American Petroleum Institute) 1581 fuel filtration standards. Other improvements may be improved flow rates, flow processes, and less head loss in the system, resulting in lighter weight and smaller volume systems. Potential new areas of investigation include new material applications, change in general process from the physical partitioning type to chemical or electrical potential processes, as well as physical

processes such as centrifugal separation. New technologies or applications of technology will only be improvements if the size, weight, efficiency, and/or practicality of system application remains nearly the same or better than the current systems.

PHASE I: Compile research paper detailing the physical and chemical processes supporting a surfactant resistant fuel filtration and water removal system, along with supporting data. Should also include a functional display model to demonstrate feasibility of the concept.

PHASE II: Develop fully functional prototype which meets API 1581 cleanliness standards for filtration and water separation when using JP8+100 fuel.

PHASE III DUAL USE APPLICATIONS: Expansion to full scale bulk fuel handling facility applications, and adaptation to on-vehicle fuel filtration systems. Surfactant resistance would present opportunity for commercial market, both aviation and automotive, to make use of improved fuel additives, and lead to decreased filtration system and fuels costs if commercial market used concurrently.

KEYWORDS: fuel, filtration, separation, coalesce, JP8+100, surfactant, dispersant

A99-090 TITLE: Semiactive Shock Absorber for HMMWV

TECHNOLOGY AREAS: Ground and Sea Vehicles, Materials/Processes

OBJECTIVE: Develop a semiactive shock absorber suitable for application on the Army's fleets of tactical wheeled vehicles; the damping medium will be based on a magnetorheological (MR) or an electrorheological (ER) fluid.

DESCRIPTION: Magnetorheological and electrorheological fluids are both rapidly advancing technologies that hold great promise of providing easily controllable damping devices simply by application of the appropriate voltage or current, respectively, across the device. The project calls for the selection of the most appropriate MR or ER fluid and development of an automotive shock absorber based on this fluid. The shock absorber will be designed to permit the damping force produced to be computer controlled for use in a semiactive suspension system. Voltage or current control to the shocks will control the damping force; computer control of the voltage/current will facilitate dynamic damping control.

PHASE I: The selected fluid capability and properties should be evaluated. The initial shock absorber will be generally sized according to the following data; application to more specific weight class trucks can be extrapolated based on proportionality of forces and suspension component sizes. Size/capability specifications: Use of 12-24 volt electrical system, to generate a minimum of 1500 lbs. damping force, minimum 2 in. stroke, withstand 4000 lbs. static tensile loading

PHASE II: A prototype shock absorber or a vehicle set (sized for HMMWV) will be fabricated and demonstrated (either on a test rig or a Government furnished HMMWV); the corresponding semiactive controller will be fabricated, integrated and demonstrated. HMMWV specification data: 24 volt vehicle electrical, minimum 2000 lbs. damping force capability, 3.5 +/- 0.25 in. stroke, 12.75 in. compressed length, 17 in. extended length

PHASE III: This technology would have application to the majority of truck fleets, both within the Army and commercial fleets; this technology will have a broad range of application, including extensive off-road applications and will be commercially pursued for selected off-road vehicles.

KEYWORDS: semiactive, suspension, magnetorheological fluid, electrorheological fluid, shock absorber

A99-091 TITLE: Sensor Technology for Detecting and Monitoring Corrosion of Land-based Vehicles

TECHNOLOGY AREAS: Ground and Sea Vehicles, Materials/Processes

OBJECTIVE: Corrosion sensors are needed to detect, determine the rate and penetration of corrosion on ferrous and non-ferrous metals. Sensors must be durable, small, cheap and either hand carried to a site or mounted/attached directly to the component. They must not adversely interfere with the functionality of the component. The sensors must also be sensitive, free of generating their own by products that can accelerate corrosion and repeatable in their output. Readings/measurements should be downloaded quickly either using RF or some other electronic downloading device. Gravimetric recordings are acceptable but are not the first choice.

DESCRIPTION: Development of sensors for corrosion detection and monitoring of metal components in accelerated test chambers and in field applications for land based vehicles are needed in the automotive community. The sensors are needed to quickly and reliably detect the rate and penetration of corrosion on ferrous and non-ferrous metals during accelerated testing and in a cyclic corrosion chamber, during and outdoor durability Bcorrosion test, and in a fielded fleet. The information



gathered must have the capacity to be downloaded quickly with a high degree of confidence and reliability. The data will be used to detect the onset and progress of corrosion on a component and also to correlate data from accelerated testing to actual environments where a customer is using the equipment. Ideally such sensors must be economical, durable and simple in their function. Information retrieval could also be done from remote locations if necessary and fed into a WINDOWS compatible Corrosion Database Management System (CORRDBMS) that will be supplied by the US Army. The sensors will or can fall into the following categories or technologies: Active sensors, passive, imaging, line of sight, acoustic, optical, chemical, magnetic etc. The data or information so gathered will be used to form a basis for developing a model for corrosion deterioration that can ultimately be used in the development and maintenance of the army's fielded fleet. The sensors will also be used to develop simulations that can replace/verify Accelerated Corrosion Testing (ACT) of entire vehicles assemblies or individual components.

PHASE I: Explore and do a search of the various sensors that are in existence, development and research. Select or design at least two approaches in meeting our stated goals. Provide a detailed rationale for the technologies that were not selected but investigated. Perform testing in the lab to confirm the design or approach(s) of the performance goals of the sensors under accelerated corrosion conditions. Write final report with recommendations for Phase II.

PHASE II: Develop and build several sensors that are to be included in accelerated corrosion test (ACT) cyclic chambers and the fielded fleet. The information gathered will be utilized to establish/confirm the correlation with the data obtained from the cyclic corrosion chamber, outdoor accelerated corrosion / durability tests with data inputs gathered from real life deployment in the field. The outputs must be statistically relevant with a desired 2 sigma degree of confidence and repeatability. The sensors must be able to track corrosion rates and level of corrosion such as penetration of the metal substrate, disbondment of surface coatings, fatigue cracking and other forms of corrosion. Upon completion of the field studies which includes downloading directly in the CORRDBMS system a final design of the sensors will be made so that working prototype and production models can be made. A final report will be written.

PHASE III: Dual use application. This technology can be used by the automotive industry to track corrosion and enhance anti corrosion design. General Motors has expressed a desire to support us in this development. The technology can also be used in aerospace, utilities, telecommunication, petrochemical and several other industries.

KEYWORDS: Simulation, Corrosion, Sensors, Accelerated testing, Detection, Vehicles.

REFERENCES: SAE 831820 P 136 "Proving Ground Vehicle Corrosion Testing" SAE 831814 P136 "A Three B Chamber Corrosion Test Method for Passenger Cars"

A99-092 TITLE: Computer Modeling the Corrosion and Durability of Land-based Vehicles

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Take advantage of recent advances in both computer technology & corrosion sensors to accurately and reliably model, simulate, and predict the corrosion, durability, and expected service life of Army vehicles and their major components.

DESCRIPTION: The Army's vehicles often operate in severely corrosive areas and in rugged environments. This coupled with decreasing maintenance funds and a need for increased service life makes corrosion a costly burden to the Army. Thus, being able to accurately & reliably predict corrosion and its combined effects with driving stresses, and associated wear on a vehicle early in its life cycle would be of great benefit to the Army. Decisions early in the design stage could thus be made on how materials, design, and manufacturing plans & process changes affect the service life of vehicles and their major components. This could eventually save \$1M & up to 18-24 months of physical testing per vehicle platform once much of the simulation could be done on the computer. Ultimately, the system will require algorithms that give results with a high degree of confidence, accuracy, reliability, and correlation with those found in the field. Corrosion sensors will be utilized and will be an integral part of data collection. The sensors can fall into the following categories: active, passive, imaging sensors, line of site, acoustic, etc. The data, together with existing Army & civilian corrosion databases, would then be used to model corrosion deterioration of vehicle systems and can ultimately be used in the development and maintenance of the Army's fielded fleet.

PHASE I: Perform literature search and explore applicable technologies including vehicle durability, dynamics simulation technologies, corrosion sensors, and corrosion/material degradation simulation & prediction. The information gathered will be used to create a prototype vehicle corrosion & durability simulation & prediction software model. This model will be used to create a final system version in Phase II. Corrosion sensors shall be used to aid in data collection, with the data to be fed into the simulation & prediction model. The model and subsequent system shall be flexibly designed in such a way that it allows for input data collection from future advanced corrosion sensors. Write final report with recommendations for Phase II.

PHASE II: Develop and demonstrate a fully working prototype computer graphical simulation system which utilizes corrosion sensors and available Army & civilian corrosion & durability field data, is easy to use and with 2 sigma reliability simulates and predicts corrosion and durability, and correlates them to actual service life for Army vehicles and their major components. The accuracy and reliability of the simulation system must be proven in Phase II. For the simulation system to be proven valid, it must correlate with the results of Army & civilian proving grounds tests for corrosion and durability. A final report with a fully working, Y2K compliant copy of the software on CD-ROM in the latest Windows compatible format with a user's manual included is required, as well as a business plan for marketing in Phase III.

PHASE III - DUAL USE APPLICATIONS: This technology could be used in many applications where corrosion/material degradation, durability, and service life predictions are needed. The technology could reduce the cost of such real world testing and could shorten product development cycles by over 50%. Potential markets include transportation sectors such as automotive, aerospace, trucking & delivery systems, hovercraft, and off road vehicle markets.

#### REFERENCES:

1. Murphy, T. "Simulation not a threat for real world testing - for now", Wards Auto World (p. 45), Nov 98.
2. G. Harris, C. Adams, & J Garber, "Use of a Corrosion Prediction Program as an Engineering Tool", NACE Technical Paper 97607 (1997).
3. T. Hakkarainen, "Transferring Corrosion Knowledge to Computers: Models for Predicting Corrosion", NACE Technical Paper 97396 (1997).

KEYWORDS: simulation, corrosion, sensors, durability, computer modeling, vehicles

A99-093 TITLE: Hyperspectral Evaluation of Signature-managed Materials

TECHNOLOGY AREAS: Materials/Processing

OBJECTIVE: The objective of this effort is to create a tool for the evaluation of narrow band optical characteristics of a complex object in backgrounds.

DESCRIPTION: The focus of this effort is to develop an evaluation tool which can accept a hyperspectral image and extract similarity and difference metrics which are useful for conspicuity and detectability. The tools should be capable of evaluation in the optical wavelengths from .35-14.0 microns. The system should also be capable of verifying reference calibration information in each of the spectral regions. A number of hyperspectral systems are in common use today which are capable of collecting necessary engineering data in the field. The problem is that no tools exist to perform these evaluations. The scope of this effort would be to develop an evaluation system based on hyperspectral data cubes of field test data. The spectral bands of interest range from the ultra-violet through the far infrared wavelengths. Determination of conspicuity or detectability for objects has up to this point been a function of systems which collect and integrate large spectral bands of data. New and emerging detection systems are focusing on multi-band data because of the increase in discrimination potential. In order to address these new sensors a better understanding of the characteristics of materials integrated on object in natural environments is required. For cases where more conspicuity is required, the same analysis techniques can be applied. These cases may include automated robotic inspection or automotive collision avoidance systems.

PHASE I: Develop the overall design and specification of the system to include interface specifications with common hyperspectral devices in use of terrestrial applications. Develop a software prototype which demonstrates the feasibility of the proposed concept to extract narrow band spectral conspicuity metrics.

PHASE II: Develop a complete and integrated system for complete spectral and spatial evaluation of field collected hyperspectral data covering visual through thermal spectral bands. This system should include complete sequence analysis, statistical analysis with conspicuity and detectability analysis. In addition the system should demonstrate a calibration function utilizing collected field calibration data.

PHASE III DUAL USE APPLICATIONS: Multi-band and hyperspectral imagery is rapidly becoming main stream in the imaging environment. The reason for this is the ability to produce a robust detection and discrimination system. As additional spectral bands are added, the variations in environment, object rotation and lighting conditions are more reliably handled. Tools like this for object characterization are prime candidates for robotic inspection, automotive collision avoidance and automated medical typing.

KEYWORDS: Hyperspectral, Conspicuity, Spectral Imaging

A99-094 TITLE: Mine-resistant Track Development

#### TECHNOLOGY AREAS: Materials/Processes

**OBJECTIVE:** To establish, and document, a set of minimum requirements that a track system and vehicle underbody must be capable of withstanding to be considered mine resistant. Requirements will be used as a basis for a specification. Identify a potential solution to meet these requirements and evaluate it through testing at APG.

**DESCRIPTION:** Current track systems have no design requirements for a minimum level of protection against mine blasts. The heavier track designs previously used may be better capable of withstanding a mine blast due to the added factor of safety from an over designed system. As the track is optimized for weight reductions, no specific requirements for withstanding a mine blast are imposed, just the basic track durability based on a mission terrain profile. This type of designing leads to an extremely light system, but it may not be able to survive anything other than small anti-personnel mines. A design with sacrificial components, or which would direct the blast in a specific pattern could be used to develop the lightest possible track capable of withstanding these blasts. All bidders will be provided a complete set of drawings for the T154 track system prior to submitting their proposal. These drawings will include roadwheels and the suspension system. It is felt that this information will be sufficient, but requests for additional drawings will be handled on a case by case basis with the potential contractor. Results from recent mine blast testing on both T154 and XT168 track will also be provided as background information during development.

**PHASE I:** This part of the program would concentrate on determining the requirements that a track would have to meet to be considered mine resistant, and to identify some potential concepts to meeting these requirements. Undercarriage design characteristics to deflect blast away for subsystems and occupants would be investigated to minimize blast damage. Different types of mines along with sizes of the charges would be looked at to determine what would makeup the requirement.

**PHASE II:** During this part of the program, a track system and undercarriage capable of surviving the requirements identified in Phase I will be produced. This will include a complete finite element analysis (FEA) of each component, as well as advanced computer analysis of the blast itself. Limited quantities of the track system will be produced for testing to the requirements detailed in Phase I.

**PHASE III DUAL USE APPLICATIONS:** Every track system used by the military and nonmilitary must provide a level of protection to the roads that they are operated on. Materials that the Government develops to increase or prolong this level of protection could also be used by the commercial industries to improve their levels of protection as well. Advances in lighter/stronger track materials and designs could be implemented by the commercial industries to increase the capacities, and performance of their vehicles. The proliferation and use of mines throughout the world and the need to clear them after hostilities cease has increased the exposure of commercial vehicles to mine hazards. This technology would also have applications in force protection, security vehicles, police bomb squads and swat teams, crowd control vehicles and a host of other commercial applications.

**KEYWORDS:** Track, mine resistance, mine blast, track designs.

A99-095                      TITLE: Portable Fuel Analyzers

#### TECHNOLOGY AREAS: Materials/Processes

**OBJECTIVE:** The objective of the project would be to develop a portable fuel analyzer and sensors capable of measuring an array of fuel quality parameters.

**DESCRIPTION:** Currently fuel analysis is performed in mobile laboratories which use time-consuming, manpower-intensive ASTM approved methods. Approximately 17 laboratories are currently fielded. Sensors for determining key fuel quality parameters placed with or mounted on tank trucks, storage tanks or pipelines would provide significant benefit by placing analysis where it is needed most. Before dispensing fuel to any receptacle, personnel could be certain that it met quality guidelines. Various technologies exist which may be applied to fuel quality analysis. Infrared spectroscopy (both near infrared (NIR) and fourier transform infrared (FTIR)) has recently been developed to the point where fuel properties may be measured quickly and somewhat accurately. However, it is not yet at the state where hand held or on-vehicle devices could perform all of the necessary tests. Another technology which has recently seen significant progress is that of particle counting in petroleum products such as fuel. With FTIR to measure fuel density or contamination such as water, and a particle counter to measure solid contamination, the analyzer could be a significant contribution to the Army's petroleum testing arsenal.

**PHASE I:** The first task as part of this phase would be to collect information regarding fuel analysis technology which is currently available and to determine which fuel quality parameters (e.g., density, viscosity, particulate contamination, etc) are most important. Following this, the field of available technologies would be narrowed to those potential candidates for

the hand-held or on-board analyzer. The final task will be to develop a conceptual design for the analyzer. A breadboard model may be constructed to demonstrate feasibility of the concept.

PHASE II: Finalize the design for the analyzer by combining technologies into an integrated, single hand held device for demonstration. The device may collect and interpret data from onboard sensors. Develop mechanism for transferring data from the sensor to a remote location.

PHASE III: Conduct field testing on a military vehicle to demonstrate product performance and operational suitability. Develop a database to incorporate sensor-provided data with fuel quality guidelines. Use of this database would enable soldiers to make decisions regarding fuel use under various situations. This database and sensor system would be extremely useful in numerous military and commercial applications. Airlines could use the sensors for lines carrying fuel from storage tanks to fueling points. Any fuel distribution system would benefit by having remote sensors with the capability of transmitting data concerning its state of quality to a central location for monitoring and control.

KEYWORDS: Sensors, remote sensing, petroleum, petroleum testing, petroleum analysis.

REFERENCES: References for fuel analysis using Fourier Transform Infrared (FTIR) and Near Infrared (NIR) spectroscopy include the following:

1. MIDAC Corporation, Examples of Fuel Analysis on Commercial and Military Fuels, 1998. This paper includes correlation plots taken from MIDAC customers who have analyzed various fuels with the Fuel FTIR Fuel Analyzer and compared the results with traditional methods.
2. Tack, L.M., J.E. Lyons, C.M. Taylor, Comprehensive Analysis of Reformulated Gasoline and Diesel Fuel Using Portable FTIR Instruments, MIDAC Corporation Application Note 127.
3. Swarin, S.J. and C.A. Drumm, Prediction of Gasoline Properties with Near-Infrared Spectroscopy and Chemometrics, SAE Paper No. 912390, 1991.
4. Fodor, G.E., K.B. Kohl and R.L. Mason, Analysis of Gasolines by FT-IR Spectroscopy, Analytical Chemistry, Vol. 68, No. 1, 1996.
5. Westbrook, S.R., Army Use of Near-Infrared Spectroscopy to Estimate Selected Properties of Compression Ignition Fuels, SAE Paper No. 930734.

A99-096 TITLE: Smart Structures for Combat Ground Vehicles

TECHNOLOGY AREAS: Materials/Processes, Ground and Sea Vehicles

OBJECTIVE: The goal is to apply smart (adaptive) structures concepts to design, develop, and test controllable devices for application in land vehicles. These devices should provide solutions to operational problems occurring in structural vibration suppression, interior noise reduction, suspension system improvement, enhanced steering and maneuverability capabilities, and structural damage detection.

DESCRIPTION: The tactical/operational vision for the Army After Next (AAN) emphasizes operation concepts that stress tactical endurance, thereby driving a set of revolutionary capabilities for ground combat systems, including (1) 50-90 miles per hour cross country, (2) 600 mile range, and (3) ten days of operation capability without resupply. This review requires an integrated systems approach and cost effective tools to understand the interactions between technologies never before considered for combat vehicle use, e.g., complex nestings of technology intensive components, such as composite materials, smart structures, distributed control, active suspension, and active protection. Smart structures consist of incorporated sensing, actuation, signal processing, and control capabilities that can spontaneously respond in real time to external stimuli to compensate for undesirable effects and enhance desirable ones. Research areas include, but are not limited to, sensors and actuators (optical, magnetic, piezoelectric, shape memory alloy, electrostrictive, magnetostrictive, etc.), formulation of suitable constitutive relations, modeling and optimal design of smart composite structures, finite element formulations and control algorithms (adaptive, robust, fuzzy logic, neural networks, etc.). Particular emphasis should be placed on improved force, displacement, frequency response capabilities of actuators. Challenges that include constitutive relations, hysteretic and cyclic loading effects, robust controller issues, fabrication techniques, power delivery systems, etc. must be confronted and overcome.

PHASE I: Develop improved sensing and actuation devices for application in combat ground vehicles. Actuation devices, for example, might include magnetorheological dampers to absorb impact in a vehicle suspension system, or structural damping treatments for vibration suppression that possess perhaps both active (piezoceramic, shape memory alloy, shunted electrical circuits, etc.) or passive (viscoelastic layers) elements. Such investigations may require the determination of basic material properties and the development of suitable constitutive relations, structural models, and control algorithms. Assess those Army vehicles that have the best potential for application and demonstration of smart structures concepts.

PHASE II: Characterize the elastic and dissipative properties of smart composite materials and active/passive damping treatments through modeling and laboratory testing. Conduct optimization studies of smart system designs taking into account both the continuous and discrete aspects of the structures (hybrid optimization procedures will be required). Demonstrate the enhanced performance capabilities of an Army vehicle equipped with smart components (e.g., improved suspension systems, robustly controlled steering system, quieter interior, more accurate performance of vibration prone mounted weapon systems, etc.).

PHASE III DUAL USE APPLICATIONS: Conceive, design, and devise smart structures based components that offer benefits to the improvement of the safety, operation, and maneuverability of both military and commercial vehicles. Improved vehicle suspension and steering systems are obvious candidates for improvement through application of active materials and adaptive structures.

REFERENCES: Toubushi, H., A. Ikai, S. Ymada, K. Tanaka and C. Lexcellent, "Thermomechanical Properties of TiNi Shape Memory Alloy," J. De Physique IV, Vol.6, C1-385 to C1-393, January 1966.

KEYWORDS: smart materials and structures, shape memory alloys, vibration, noise, damage, composite materials, strain, piezoelectric

A99-097                      TITLE: Video Compression for Standard Teleoperation Kits

TECHNOLOGY AREAS: Materials/Processes, Ground and Sea Vehicles

OBJECTIVE: Design, build and demonstrate a video compression (VC) module to attach to the DoD Standard Teleoperation Kit. This module will enable the kit to operate in a low bandwidth tactical communication mode. It will also enable the kit to simultaneously send multiple video signals back to the control unit without adding an additional video link. This will enable the kit to operate with stereo vision.

DESCRIPTION: Advances in a variety of VC techniques will facilitate the transmission of one or more video signals over a significantly reduced bandwidth communication system. This is particularly desirable to adapt the teleoperation kit to a standard tactical radio system. The current DoD Standard Teleoperation Kit employs a standard video link operating at significantly higher bandwidth than a tactical radio, e.g. SINCGARS. The integration of the VC technology with the teleoperation kit and a tactical radio will provide a capability for some non-line-of-sight operation not currently available.

The VC module applied to the kit will also provide stereo vision capability to the teleoperator. Simultaneous video signals, from a pair of video cameras mounted on the teleoperated vehicle, will be compressed and transmitted over a single receiver-transmitter pair. The stereo vision will provide the teleoperator with enhanced depth perception. The depth perception will allow the teleoperator to view in much greater detail obstacles such as ditches, craters, fallen trees prior to vehicle negotiation. Specific requests for information on SINCGARS or the Standard Teleoperation Kit by interested contractors should be directed to Jerry Lane USATACOM AMSTA-TR-R MS 205, Warren MI 48397-5000 or Telephonically: 810-574-6683 or E-MAIL: laneg@tacom.army.mil.

PHASE I: The conceptual approach will be developed and initial design modifications formulated to integrate video compression and the tactical radio to the Standard Teleoperation Kit. Phase I will include the selection of video compression algorithms; component selection including processor boards, monitors, and stereo cameras; software flowchart development for the modifications; component placement; stereo vision adaptation of operator control unit; and teleoperation range, mobility & visual obstacle detection performance predictions.

PHASE II: The contractor will complete the design, fabricate the components, adapt the software, integrate the system on a government furnished combat vehicle, perform checkout tests, debug the software modifications, and support government warfighting experiments. Contractor checkout will include developing performance baselines to include the documentation of performance improvements in tactical radio teleoperation range and obstacle negotiation performance based on depth perception improvements from stereo vision. Subsystem checkout will verify the reliability of the software modifications and the durability of the hardware modifications.

PHASE III DUAL USE APPLICATIONS: The system can be used in various hazardous situations where precision driving or manipulation is required e.g. fire extinguishing, mining, construction in soft soil, etc.

KEYWORDS: Stereo Vision, Teleoperation, tactical radios, communication bandwidth, and video compression

REFERENCES: DoD Unmanned Ground Vehicle Master Plan

A99-098

TITLE: Recycling of Discarded Rubber Tires

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a process that reconstitutes recovered rubber crumb from the Army's discarded rubber tires into a product that approaches the chemical and physical properties of virgin rubber.

DESCRIPTION: The recycling of automotive tires is not new but previous results have not been impressive and the content of recycled rubber in new products has actually diminished. Most of the products have been used for corrosion control, shredded chips as a playground material, low-grade rubber mats or in some cases, clothing and accessories that are more novelty than practical. Recent advancements have resulted in numerous cost effective methods to separate useable rubber crumb from discarded tires. Plastics used to be the environmental scourge of the environmental movement- not so today. Significant emphasis was able to influence the Research and Development of methods and processes to recycle the discarded material into very useful end products. The significant difference between recycling of plastic and rubber is that most plastics (approximately 90%) are thermoplastic in nature while only approximately 6% of rubber is. Pneumatic tires are thermoset with a chemical change that presently is irreversible.

PHASE I: Develop a processing system that reverses the vulcanization inherent in recovered rubber crumb, by adding the appropriate recipes of chemicals, filler material, and temperature control. The resulting raw material will approach the physical and chemical properties of virgin rubber.

PHASE II: Demonstrate the capability of this raw material to be further processed into complex product that exhibits the similar properties of like product made from virgin rubber.

PHASE III DUAL USE APPLICATIONS: Dual Use Science and Technology applications that could provide an enormous market for the millions of Army scrap tires resulting in a cleaner environment and the conservation of a natural resource.

REFERENCES: Charles P. Rader and Marvin A. Lemieux, "The recycle of plastics and rubber-a contrast", RubberWorld, May 1997

KEYWORDS: rubber, rubber crumb, vulcanization, environment, environmental quality, natural resource, thermoset, tires

### **U.S. Army Topographic Engineering Center (TEC)**

A99-099

TITLE: Semantic Mapping Tools

TECHNOLOGY AREAS: Information Technology Systems

OBJECTIVE: Develop tools to support the automation of semantic translation of geospatial data (generated using many different feature dictionaries) to feature dictionaries that are understandable by Army systems that will exploit this data.

DESCRIPTION: Background: Semantic heterogeneity is one of the primary limitations that hamper the widespread ability to share geospatial data. Much of the existing geospatial data contains semantic information that is unique to each database. Software applications that are developed to exploit geospatial data are tailored to these "database specific" or "agency specific" semantics, and are limited to a number of data sets. For example, an application that assesses vehicular mobility across the open terrain is tailored to specific feature and attribute types, and domain values captured in slope, soils, and vegetation information. To use these applications on data with different semantics, it is necessary either to make changes to these applications, or translate the semantics contained in this new geospatial data source into the application's semantics. This is often a very cumbersome (perhaps impossible) process; consequently, new geospatial data sources are rarely used. In addition, queries that rely on semantic information must be tailored to the semantic information contained in a given data set. For example, a query on a database for all "primary, divided highways in Omaha, NE" must query on those exact terms. Therefore, in order to generate a query that uses semantic information contained in a geospatial database, it is necessary either to know, or expose and examine, the semantics of the database. Scope: The focus of this project will be to develop semantic mapping expert tools to automate the laborious process of identification of potentially related terms for semantic mapping. Additionally, this project will develop the capability to export the necessary information to support the capability of spatial data translation tools to translate a dataset from one feature dictionary to one useable by Army application software.

PHASE I: Perform an study and evaluation of existing technology and methods to that could be incorporated into expert semantic mapping tools to automatically identify potentially related terms for semantic mapping. Evaluate existing and

developing commercial technology that provide a capability to translate the semantic information contained within spatial databases to a feature/attribute/domain scheme that is common to Army/DOD systems that exploit geospatial data.

PHASE II: Develop and test prototype semantic mapping tools using heterogeneous feature dictionaries and "one of a kind" feature information captured in unique spatial databases. Test the "hand-off" of this semantic mapping information to available spatial database translation tool(s).

PHASE III DUAL USE APPLICATIONS: Applications that provide solutions to semantic mapping of geospatial data are needed by all consumers of spatial data. Semantic heterogeneity is a widespread problem that is found across the multitude of communities that generate and exploit geospatial data since much of the existing geospatial data contains semantic information that is unique to each database. This is especially true of organizations that generate geospatial data for state-, county-, or municipality-level applications, as well as for private industries--such as utility companies. At the Federal level, many of the agencies that generate geospatial data have "agency specific" semantics. These Federal agencies may use the same semantics for a series of geospatial databases (or products). Consumers of geospatial information, especially those that attempt exploit data generate from multiple organizations, are challenged with the task of attempting to analysis each dataset and determine the semantic mapping between what is contain within these datasets and what is encoded in their applications. Therefore the development of tools to identify the semantic mapping that support the translation of spatial databases between feature dictionaries is a commercially viable capability needed by all consumers of geospatial information, e.g., Federal, state, and local governments, and private industry (e.g., utilities, map producers and GIS consulting firms, etc.).

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KEYWORDS: Semantic translation, semantic mapping, spatial database,translation

## **U.S. Army Test and Evaluation Command (TECOM)**

A99-100 TITLE: Remote Autonomous Zoned Optical Range

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Design and development of the hardware necessary to provide autonomous remote operation of tracking systems.

DESCRIPTION: Develop fleets of small, high-performance, portable weatherproof optical tracking systems that run remotely and autonomously. This effort will decrease manpower operational requirements. Considerations should include using high-speed digital cameras as sensor sources and differential Global Positioning System for self-locating and automatic range calibration. The desired setup scenario should primarily address setting the unit on the ground, providing and activating a power source, and involve minimum site preparation. This will also allow the units to be precisely located for optimal tracking coverage with minimal environmental effects. Remote control would be established through a radio network to avoid requirements for optical fiber or copper cabling. These units could be located directly under trajectory paths or anywhere a truck or helicopter could set them.

PHASE I: Definition of the design parameters and configuration(s) required to achieve a solution to the problem. Phase I should include a review and analysis of current tracking platforms and operations in order to evaluate their suitability as a solution to the problem.

PHASE II: Develop a prototype tracking platform system that will interface with existing range control systems. Demonstrate the system by tracking dynamic aerial and ground based targets under a variety of conditions.

PHASE II DUAL USE APPLICATIONS: The addition of a small platform that can be placed almost anywhere will enhance the marketing capability of existing tracking systems. Commercial uses are found in dynamic testing environments such as found in the aerospace industry and automobile testing (performance, crash testing, etc), automatic monitoring of ground traffic under adverse conditions with IR sensors (airports, harbors, freeways etc). Suitable applications are also found in work performed by NASA, FAA, other DoD activities and MRTFB ranges.

KEYWORDS: remote autonomous zoned optical range



A99-101

TITLE: Solid State Oxygen Concentration Measurement System

TECHNOLOGY AREAS: Ground and Sea Vehicles

OBJECTIVE: Develop and verify the performance of a portable, multipoint solid-state oxygen sensor system for measuring oxygen concentrations in vehicles and fixtures during fire tests. Continuous oxygen concentration data are essential for evaluating the performance of fire extinguishing agents and/or systems during full scale testing. Failure to account for oxygen depletion within the test volume can result in overestimation of the agent or system performance.

DESCRIPTION: The oxygen measurement system should consist of a data acquisition (DAQ) module with multiple, easily replaceable oxygen sensors having the following characteristics: 1) The sensors shall produce a current or voltage output proportional to the oxygen concentration measured (0 to 25%), and shall be temperature compensated from 0 to 1500oF. Sensor leads, equipped with standardized or commercially available connectors, should be approximately 5-m long, and shall be shielded and insulated as required to prevent signal interference and to withstand temperatures of up to 1000oF for up to 1-minute. Sensor size shall be minimized in Phase I; the Phase II sensor shall not exceed 50-mm diameter by 75-mm length. Sensor response to a step change in oxygen concentration shall be less than 1-second to 90% of full scale 2) The DAQ module shall provide power to the sensors, acquire data, apply temperature compensation and signal linearization, and convert the output to digital format for transmission to a remote computer using a suitable communications protocol (serial, ethernet, etc.) Data acquisition rates shall be a minimum of 10-hz per channel and shall be in a format suitable for direct importation into a spreadsheet such as Excel. The DAQ shall operate on 12 or 24V DC power.

PHASE I: Investigate available solid state sensors (i.e.: automotive sensors) and develop and build a prototype two channel system, test under actual fire conditions, and make changes/improvements as required to achieve the desired performance. The system shall be designed to avoid interferences (positive or negative) from chemical species commonly found in fire situations such as: hydrocarbon fuels, carbon dioxide, carbon monoxide, or hydrofluorocarbon fire extinguishing agents. A calibration procedure shall also be developed.

PHASE II: Implement the design developed in Phase I and build one prototype system to demonstrate performance during hydrocarbon fire test conditions.

PHASE III: Implement the design with modifications demonstrated during Phase II and build two 10-channel systems, with 100% spare sensors (20), that is weatherproof and easy to field. Demonstrate overall system performance, integration and DAQ compatibility.

DUAL USE APPLICATIONS: This system will have applications for fire and combustion research, and possibly for feedback control of fuel burning systems.

KEYWORDS: Oxygen sensors, data acquisition

A99-102

TITLE: Ordnance Detection

TECHNOLOGY AREAS: Materials/Processes; Sensors, Electronics, and Battlespace Environment

OBJECTIVE: New or novel technology is solicited for the detection of concealed or buried unexploded ordnance (UXO). Of specific interest is the UXO that litters the test and training ranges throughout the US and abroad. UXO at such ranges may vary from pre-World War II high explosive (HE) artillery rounds to sub-munitions from today's most modern weapon systems. Also, included in the category of UXO, for this topic, are depleted uranium rounds used for anti-armor applications. The test and training range UXO problem is exacerbated by the fact that the contamination has often been on going for decades and the land areas involved often encompass hundreds even thousands of square miles. Obviously, conventional techniques for locating UXO are not well suited for the test and training range environment. It is expected that any technology developed by this topic will have wide applications, not only on test and training ranges, but also by military and civilian entities reclaiming UXO contaminated areas resulting from war or terrorist activities. Any method or technology developed must provide for maximum personnel safety and minimal disruption to the environment.

DESCRIPTION: Live ordnance litters many former battlefields and test and training ranges throughout the US and abroad. Current techniques for actively locating unexploded ordnance rely heavily on a man in the field approach to physically search for the ordnance. This method is inefficient and presents extreme personnel hazards. Due to the difficulty of this problem, large contaminated areas remain off limits for indefinite periods. Technology is sought that will yield a highly accurate and safe means of locating UXO over large areas. The technology is to be integrated to a Geographic Information System (GIS) to expedite the mapping of UXO for later disposal. This new technology or method will dramatically increase personnel safety and efficiency of UXO detection by allowing operation from standoff vehicles such as helicopters, unmanned aerial vehicles,

remotely piloted vehicles, etc. Significant UXO detection research is being performed by the DOD and has had some success. A "fresh" approach to detecting UXO is solicited. No solicitations replicating past research will be accepted. Additional details on current and past research can be found at the Office of the Secretary for Defense (OSD) UXO web site, <http://www.denix.osd.mil/denix/Public/News/UXOCOE/uxocoe.html>.

PHASE I: The investigator shall conduct the necessary analysis and research to develop a highly efficient yet environmentally safe technology for the detection of buried ordnance. The analysis and research shall provide the basis for a prototype development in Phase II.

PHASE II: The investigator shall proceed with prototype development and demonstration of the technology proposed in Phase I.

PHASE III DUAL USE APPLICATIONS: There is a tremendous world wide application for a technology that can effectively detect explosive devices. Obvious activities include the reclamation of former battlefields and test ranges. This technology will also be used by anti-terrorist organizations providing building and event security. Additionally, it will be suitable for detection of contraband explosives entering, exiting or being transported within a country. Weapons developers and testers will also be able to use the technology to quickly and efficiently evaluate munition dispersion patterns.

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3. New Mexico Tech, Public Information Office, <http://www.nmt.edu/mainpage/news/landmine.html>
4. SPIE-AeroSense98, [http://www.spie.org/web/meetings/programs/or98/or\\_confs/3392.tml](http://www.spie.org/web/meetings/programs/or98/or_confs/3392.tml)
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KEYWORDS: unexploded ordnance, sensors, minefield

#### U.S. Army Waterways Experiment Station (WES)

A99-103      TITLE: Device for Measuring Response of Windows and Window Retrofit System

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVES: To design and demonstrate an inexpensive method of measuring dynamic response of blast-loaded windows, including window retrofit systems.

DESCRIPTION: Recent emphasis by the Government on protection of facilities from acts of terrorism has led to the search for building components that are more blast resistant or reduce blast hazard to personnel. Debris hazard from failure of windows is responsible for a major part of the injuries and deaths due to terrorist attack. Window failure and debris transport are reduced by the use of window retrofit systems, including window film and catcher bar systems. Experimental verification of the design of retrofit systems currently includes high-speed photography to document window failure, debris velocity, and retrofit response/performance. Photographic methods are limited by the debris cloud itself and space confinements in the receptor room that limit the viewing angle and viewing extent of the camera. Viewing angles when catcher bar retrofits are used are even more limited. A more desirable approach is a device that can measure initial window velocity; impact velocity, including time of impact of the window/film system onto the catcher bar; catcher bar response; rotational velocity of the window/film system as it wraps around the catcher bar; and debris velocity of any glass fragments that escape the retrofit system.

PHASE I: Provide concept design of the measurement system and demonstrate feasibility in an experiment.

PHASE II: Develop the most promising concept design and build prototypes for use in blast experiments.

PHASE III: This system would have potentially wide use by companies interested in providing building products to increase the blast resistance of windows. These would include various window and glazing manufacturers. In addition, other Government agencies faced with the need for increased blast resistance of facilities may find use for this device.

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KEYWORDS: blast response measurement, windows, window retrofits

A99-104 TITLE: Bistatic Radar Measurements and Inversion Modeling

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVES: To design, develop, and test a computer model algorithm for inverse microwave scattering capable of reconstructing structural profiles from data collected using a bistatic radar measurement system. The goal is to re-create images of the interiors of man-made structures that possess signature control and structural hardening materials by inverting the data obtained from a controlled, bistatic, microwave, remote sensing system.

DESCRIPTION: Recent developments in high-quality microwave remote sensing systems indicate that it is now possible to invert microwave scattering data to obtain imagery models for man-made structures. Both commercial and military operations often require the deduction of physical properties, such as size, shape, and electromagnetic characteristics, from a structure or object. The source of data for calculating the internal construction structure must be from radar electromagnetic wave since this is the only physical mechanism capable of non-destructive penetration of commercial and military structures for which data are required. This technique is generally known as the inverse scattering problem. Generation of permittivity and conductivity profiles of unknown media can be accomplished through the application of 1-dimensional inverse scattering techniques. In these techniques, information included in the scattering data is utilized to reconstruct 1 and 2 dimensional profiles. Subsequently, several profiles for different transmitter/receiver combinations can be assimilated into a scattering based tomographical image which will cross-sectionally describe the internal material state of the structure. This is accomplished using transmitter/receiver tandems under the constraint of limited angle of access to the structure. An analogy to this process is the use of tomography to measure human internal organs. The measurement techniques involves a multidisciplinary approach to the analysis of electromagnetic wave propagation, the study of wide-band antenna and radar systems, nondestructive testing, subsurface detection, geophysical exploration, signal and image processing, noise reduction, remote sensing and target identification. This research is motivated by high-use commercial and critical DoD requirements for hidden object detection/ identification, damage assessment, and camouflage discrimination. One goal of the work will be to develop an algorithm for a 3-dimensional reconstruction and to verify it using experimental data from scale model test structures. Then, the limited angle scattering based tomography technique will be evaluated and compared with traditional techniques through the transmitted full angle tomographic reconstruction procedure, using both simulation studies and experiments. The proposed effort will involve an equal emphasis on equipment preparation, theoretical development, modeling and analysis, and experimental validation.

PHASE I: Design the software and create an applications program interface for the data acquisition using the bistatic measurement facility necessary for the measurements described above. Develop inverse microwave scattering algorithms capable of creating tomographic models of man-made structures from data. Provide a specific set of planned bistatic measurements and software validation techniques to support the algorithm development process.

PHASE II: Develop data acquisition control software, systems components, and user's manuals for implementation on a bistatic microwave measurement system. An experiment design is required for a set of planned measurements necessary to validate the system and the software for displaying the tomographic image reconstruction from the inversion of the microwave scattering data. Conduct measurements for a validation study and provide the results for each algorithmic approach used on a specified structure type. All microwave inversion imagery should correlate with physical measurements of the structures used in the experiments.

PHASE III: DUAL-USE COMMERCIALIZATION: The results of this research will have a broad-based commercial potential for application in sensor and imagery interpretation algorithms development in both civilian non-destructive structural evaluations, and military reconnaissance and surveillance systems. Products from this research would provide new information for multispectral signature control, structural hardening, battle damage assessment, disaster response, non-destructive evaluation of bridges, and rescue from collapsed buildings.

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KEYWORDS: bistatic, RCS, measurement, radar, CCD, radar scattering

A99-105 TITLE: Miniature Blast Sensors for Conventional Weapons Effects Studies

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop miniature air blast and ground shock/motion sensors for use in miniature-scale, precision high-explosive experiments.

DESCRIPTION: The Engineer Research and Development Center, Waterways Experiment Station conducts miniature-scale precision weapons effects experiments and structural response experiments in its laboratory facilities. These miniature-scale of these experiments enable researchers to achieve much greater control of the initial and boundary conditions of experiments, allow for better definition of the blast environments and structural responses created in the experiments, and allows experiments to be conducted several times to define the statistical nature of the data gathered. Miniature-scale experiments save time and money over similar experiments conducted at full- or near-full scale. To better conduct such experiments, very small precision pressure, ground shock, and motion sensors are needed. These sensors must be no more than approximately 1 mm thick in the sensing direction, and no more than 5-6 mm wide normal to the sensing direction, to achieve the desired accuracy at the experiment scales of interest. In addition, the sensors must have a frequency response on the order of 1 MHz and be able to withstand shock environments of well over 10,000 g's and peak pressures/stresses from 0.7 MPA (100 psi) to 340 MPA (50,000 psi). Innovation will be needed to develop rugged sensors of this size and capability.

PHASE I: Design and predict the performance of prototype gages for use in miniature-scale weapons effects and structural response experiments.

PHASE II: Refine the gage designs and produce working gages for use in miniature-scale weapons effects and structural response experiments.

PHASE III DUAL USE APPLICATIONS: Rugged, small-scale blast gages have an extensive market throughout the R&D community that studies shock physics and structural dynamics. This market includes the automobile and aircraft safety industry, as well as the mining industry.

REFERENCES: Welch, C.R.; Rinehart, E.J.; "The Effect of Experiment Scale On Ground Shock Measurement Error," Proceedings 7th International Symposium on the Interaction of the Effects of Munitions with Structures, Mannheim, Germany 24-28 April 1995.

KEYWORDS: sensors, weapons effects, miniature-scale, shock physics, structural dynamics, blast effects, ground shock, air blast, lethality, survivability, explosive effects

## Topics Addressing U.S. Army Operating and Support Cost Reduction (OSCR) Initiatives

### U.S. Army Armaments Research, Development and Engineering Center (ARDEC)

A99-106 TITLE: Innovative Structural Control and Devices using Smart Material Technologies

TECHNOLOGY AREAS: Weapons

**OBJECTIVE:** Develop hybrid high performance actuators and devices and associated driving electronics and controllers for integrated or imbedded structural control. The actuators or devices should provide high force/torque and large displacement capabilities with a large dynamic response for precision positioning, vibration isolation and biomimetic applications. The devices should be compact, low cost, have high stroke and load capability and have low power requirements. Ideally, actuators or devices shall be self-contained, imbedded or easily integrated with host systems or structures.

**DESCRIPTION:** Numerous weapon, biomimetic and commercial applications require high bandwidth (often in the 100-1000Hz range), and large displacement (.1mm - 10mm), structural control systems that can be readily incorporated into the structure or components of the system without major modification. This is particularly critical in structural applications in which even minor change in the component/structure geometry/shape may significantly compromise the performance of the system such as, large caliber tank and artillery guns, 50 caliber machine guns, 30mm B 40mm chain guns and even individual crew served weapons. Additionally, weapon platform mount structures, like the roof of a HMMWV for example, or sensor support mast structures can be improved to minimize platform size and weight burden while improving performance. Ongoing efforts utilizing micro and mesoscale biomimetic systems will directly benefit from this effort. The dynamic requirements of such devices will eventually be dependent on specific applications but for a technology development effort as defined by this topic it is anticipated and acceptable to design hybrid sub-scale actuators and devices and demonstrate these devices on representative surrogate structures. Sensor and actuator technologies can be integrated and embedded to form novel state-of-the-art structural control devices. These designs will most probably be based on smart materials capable of high speed actuation or damping and require specialized drive, mechanisms and control electronics. This project will address issues related to the development of such innovative actuators or devices, including the design concepts and methodology, modeling, simulation, prototyping, and real-time software/hardware implementation for a number of such designs with the greatest potentials.

**PHASE I:** Develop concepts and configurations, control laws, and implementation ideas. In Phase I, a comprehensive assessment and analysis of possible active material based actuators or device concepts for structural design and control should be conducted. The strength and weaknesses of the different ideas should be evaluated. The best configuration(s) should be identified. Concrete designs of one or more of the best system(s), including the devices, controller, driving electronics and structural members or structural integration are expected. The conclusions should be demonstrated and verified through computer simulations and component level lab tests.

**PHASE II:** Develop a fully integrated design, test and prototyping environment for development of the selected structural control devices. A prototype system should be developed for a specific military application during this phase of the project that would achieve a higher performance in pointing systems, vibration control or structural optimization. These structural systems or control devices should be prototyped, fully tested, and integrated in existing systems. As part of this effort, modeling and control design of the structure or pointing system should be accomplished in order to demonstrate successful applications of the technology. Production and manufacturing issues shall also be addressed in Phase II.

**PHASE III DUAL-USE APPLICATIONS:** Smart materials based structural control devices or members have a high demand in both military and commercial applications. A number of commercial systems and machinery also require added low cost actuators or devices for performance enhancement or structural optimization. Such commercial systems are machines such as laser and electron and X-ray beam lithography machines, inspection and probing machines for the electronics industry, automated quality control and metrology related machinery, laser and antenna pointing systems and machinery for the production and testing of ultra-high quality optical components and instruments. Furthermore, such devices may be utilized both for positioning and vibration isolation purposes.

**KEYWORDS:** smart structures, actuators, dampers, smart materials, vibration isolation, precision pointing, active-passive hybrid actuators, imbedded structural actuators

**OPERATING AND SUPPORT COST (OSCR) REDUCTION:** The integration of smart material based structural control actuators or devices has demonstrated great potential for the reduction of operating and support costs by improving the accuracy and lethality of weapon systems making them more efficient at meeting mission requirements. These structural control devices can often replace conventional hydraulic or electric actuator systems and over designed/non-robust damper or vibration reduction systems reducing scheduled maintenance, safety and environmental impacts and the cost of spares.

Additionally, the imbedded or integrated design of these devices within host structures or systems can often reduce or minimize the structural weight and platform burden while improving performance capabilities through structural optimization.

A99-107

TITLE: Intelligent Multi-agent Hybrid Systems Control Technology

TECHNOLOGY AREAS: Weapons

OBJECTIVE: Develop algorithms, design methodology and processing architectures to support implementation of real time multi-agent and hybrid systems control technology for coordinated, rapid response, multi-target/ multi-platform fire control applications. Demonstrate and validate technology for distributed fire mission engagement.

DESCRIPTION: Recently progress has been made (see ref) in developing hybrid/multi-agent processing algorithms, design methodology and architectures to support distributed intelligent decision making, planning and real time control which makes feasible the design and implementation of multi-agent control strategies for coordinated multi-platform weapon engagement. Further development is required to mature this emerging technology, optimize algorithms and hardware/ software implementation architectures and validate the concept in a realistic scale engagement simulations. Key requirements of the multi-agent architecture are a) real-time performance b) reactive, event driven behavior 3) adaptive/ on-line learning based on sensory data 4) distributed decision making and coordination 5) support for multiple levels of abstraction in reasoning and control 6) distributed reasoning in the presence of uncertainty 7) information fusion 8) target track management and deconfliction and 9) design flexibility for reconfiguration to different platform mixes, mission requirements and sensor configurations. This project will address the broad spectrum of issues associated with the development of prototyping tools and design methodology, hybrid system modeling and multi-agent simulation, real time hardware/software implementation, multi-agent algorithm development, and human-computer interface.

PHASE I: Develop methodology, computational approaches and architectural concepts to support design and implementation of multi-agent hybrid system control laws for distributed multi-platform applications. To demonstrate the generic nature of the multi-agent framework and methodology adapt the problem formulation to the multi-target- multi-platform engagement application and also illustrate applicability to distributed process control and scheduling. Problem formulation should take into account physical constraints and characteristics of sensor/actuator subsystems as well as inter-platform communication and network constraints. In the case of the fire mission application, such constraints would include pointing accuracy, slew rates, rate-of-fire, sensor characteristics, tactics, etc. Phase I will formulate multi-target-multi-platform engagement strategies that optimize use of shared information and resources and maximize hit probability and engagement effectiveness and provide preliminary performance analysis. Phase I will also identify specific software development and design tools, provide preliminary concept definition and specification of implementation environment.

PHASE II: Develop a fully integrated design and prototyping environment to support generic multi-agent control applications. The design environment will include hybrid system modelling and simulation tools, and agent design and prototyping tools to support application development, implementation and testing. Develop detailed agent algorithms, application scenario, and multi-agent software and hardware prototype and evaluate via simulation. Optimize module hardware/software and algorithm design based on test data and provide complete documentation of algorithms and hardware/software architecture.

PHASE III DUAL USE APPLICATIONS: This work has a very high probability of commercialization. The methodology, design environment, prototyping tools and component technology developed in this SBIR are applicable to manufacturing, machine tool, process control, smart highway systems and distributed robotics. These applications are characterized by the presence of discrete event and continuous time dynamics which are tightly coupled and require hybrid design methods to ensure performance and stability. This technology also has broad DOD applications, particularly in the area of affordable controls; distributed, multi-platform fire control and targeting; intelligent, multi-agent, cooperative systems; defense manufacturing, etc. The impact of the technology is two-fold: increasing performance through improved control software while reducing cost by encouraging reuse and improving reliability, maintainability and fault tolerance.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Multi-agent processing technology will permit optimal utilization and distribution of assets on the battlefield as well as reduce training and personnel requirements by enhancing automation of crew functions.

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3. Hybrid Knowledge Bases, Trans on Knowledge and Data Eng. 1996;
4. Adaptive Probabilistic Networks With Hidden Variables, Machine Learning, 1997;

5. Conflict Resolution For Air Traffic Management Systems: A Study in Multi-Agent Hybrid Systems, IEEE Transactions on automatic Control, Spec Issue 1997;
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KEYWORDS : Hybrid control technology, intelligent multi-agent processing architecture, multi-platform, fire control

A99-108 TITLE: Proficient Gun Barrels

TECHNOLOGY AREAS: Weapons

OBJECTIVES: Design and build a proficient gun barrel able to acquire and display unique operational and functional awareness. Introduce the necessary devices, sensors and/or smart materials, etc. with embedded logic into the gun barrel to achieve these aims without resorting to excessive power sources or weight penalties.

DESCRIPTION: In recent years, the past initiatives in the research and development of smart or sensor materials as well as micro-electrical mechanical systems (MEMS) have evolved to the stage where they can now demonstrate unique abilities to respond to external stimuli and provide analog responses. Piezoelectric materials, electrorheological fluids and shape memory alloys are representatives of this class of smart/sensor materials. When incorporated into a structure in an innovative manner they imbue that structure with awareness abilities that can uniquely combine both sensing, control or monitoring features. Gun barrels have not fully taken advantage of these unique materials to improve their operational performance and provide real time functional awareness when they are often subjected to aggressive firing schedules. For example, judicious incorporation of these materials can provide an adjunct level of autonomous operation for specific gun systems that is both cost effective, performance enhancing and safety related. Two areas of functional awareness that can be considered performance enhancements are real time monitoring of barrel wear/erosion and round exiting velocity.

PHASE I: Develop an overall system architecture for gun barrel operational and functional awareness. Incorporate sensor, smart material or MEMS, etc. specifications and modal operational criteria. Address as many aspects of gun barrel performance factors as deemed appropriate to achieve functional awareness levels commensurate with enhanced safety, performance and extended life.

PHASE II: Develop and demonstrate a prototype system in a realistic Army firing schedule with Army supplied gun barrels. Conduct testing to establish proof of principle, fabrication feasibility and system endurance.

PHASE III DUAL-Use Applications: This system would have potential utility in commercial engine monitoring as well as in providing new algorithms to enhance functional awareness with commercial products.

OSCR REDUCTION: Presently the DOD spends a lot of money for premature failure of gun barrels. Developing a cost efficient system that accurately assesses gun barrel performance and available life would facilitate the more accurate projection of inventories

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KEYWORDS : Gun barrel, sensors, smart materials, functional awareness

A99-109 TITLE: Acoustic Mine Detection and Neutralization

TECHNOLOGY AREAS: Sensors, Electronics and Battlespace Environment

OBJECTIVE: Develop a state-of-the-art acoustic mine detection system capable of detecting and neutralizing existing and next generation land mines.

**DESCRIPTION:** Based upon the growing concern over the number of existing land mines which have been left in place during conflicts, and the number of civilian casualties as a result of these uncleared areas, there is a growing need for the ability to efficiently and effectively detect and dispose of land mines. This problem is compounded by the fact that as a function of time, the sophistication of land mines has increased, and the ability to be detected has been significantly diminished due to the utilization of new materials. Current systems either cannot detect new land mines, or the detection times are too long and not reliable, and thereby are virtually prohibitive. Although the basic focus of the effort is toward Anti-personnel Landmines which are typically buried near the surface, this technique could be utilized for other types of mines such as antiarmor mines which are typically buried about five inches below ground. The intent of this system is to acquire and disable both existing and new systems in a fraction of the time currently achievable with a relatively small rate of false alarms. For those detected cases of initial false alarms, the system would be used with more resolution to interrogate and confirm the validity of the false alarm to ensure that once an area has been cleared no active landmines remain.

**PHASE I:**

A. **Detection:** Identify existing state-of-the-art mine acoustic detection systems which are potential candidates to identify land mines. This could include the combination of detection techniques, which will provide both high resolution and high scan rates, with low rates of false positives. It is envisioned that the resultant concepts would utilize a fusion of acoustic sensor and acoustic source technologies with the combination of advanced visualization comparison technologies. During operations, initial soil calibrations would be done and potentially referenced to an existing "look-up" table which would contain pertinent information about known soil conditions. In addition, "look-up" table could be utilized to minimize processor times, and hence scan times for pertinent mine information. It is envisioned that the first stage, the scanning phase, would utilize a low power acoustic source to excite the surrounding air and ground. This would provide an initial signal to the sensor as well as excite the ground which the mines would be buried in and provide a reflection back to the sensors. The scanning phase would provide a high scan rate with relatively low resolution. The output from these series of sensors would utilize state-of-the-art logic and would ensure that if the system detected a potential mine, a positive result would register. This portion would error on the side of identifying false positives as potential positives to ensure that any and all potential mines would be detected. At this point, once a potential positive was denoted, the determination/validation mode would become the dominant function of the system. This portion of the detection process would be of a slower scan rate, but significantly higher resolution. This stage of the process would clearly determine the potential positive(s) as denoted in the scanning phase. Once again, if the determination/validation phase of the detection process would always error on the side of a false positive, it would ensure any and all potential land mines would be denoted for neutralization.

B. **Neutralization:** This phase will determine the sensitivity of the mine initiation process to acoustics and determine the vulnerable thresholds for various components, subsystems, and the total system of various surrogate mines. This will utilize the output information such as location, and type of mine, etc., as previously determined in the detection mode. The landmine initiation sensitivity information obtained during this phase will ensure that the acoustic energy utilized during the detection mode does not inadvertently initiate the mines, and to also ensure that once a mine is located, it is subjected to sufficient acoustic energy to ensure detonation. During the neutralization phase the mine should be subjected to an excess of 1 to 2 orders of magnitude higher acoustic energy density (flux) than is required to detect the landmine. This approach will ensure that the landmine will be neutralized.

C. **Demonstration:** Experimentally confirm/verify the sensitivity analysis for both Detection and Neutralization by utilizing surrogate mines or representative components for different classes of mines. A series of parallel approaches will be utilized, i.e., Phase IA and IB would be performed in parallel to minimize development time. The Demonstration portion, Phase IC could be done either independently or congruently

**PHASE II:** Combine the two (2) systems developed independently during Phase I and combine the units into a single brassboard system. In addition, experimentally confirm/verify the capability to detect and neutralize several surrogate, representative, mines.

**PHASE III DUAL USE APPLICATIONS:** This technology has numerous applications in the law enforcement as well as counter terrorism areas. This tool could be utilized either in the joint mode of detection and neutralization or independently. For buildings or areas which would require constant monitoring for munitions activities, this device could store an acoustic footprint of the building/area, and via comparison of the current trace to the baseline data, a proactive counter terrorist effort could be maintained. In addition, in the area of countering drugs, during raids on manufacturing and storage facilities, this tool could provide "real time" entrance into these safeguarded areas.

**KEYWORDS:** Landmine technologies, sensors, acoustics, neutralization, lethal mechanisms

**OPERATING AND SUPPORT COST REDUCTIONS:** By providing the Unit Commander and the operator with "real time" detection and neutralization of land mines, the vulnerability of the forces is significantly reduced as compared to previous systems, and the ability to detect and neutralize occurs in seconds as opposed to minutes, if at all. This will allow the Commander the ability to accomplish not only his mission faster, but also with significantly fewer personnel. This will result in the overall reduction of operational cost.





## U.S. Army Research Institute (ARI)

A99-110

TITLE: Training Adaptability in Digital Skills

TECHNOLOGY AREAS: Human Systems

**OBJECTIVE:** Develop an innovative package of training strategies and practical techniques to facilitate the retention and transfer of "old-system" digital skills and acquisition of "new-system" digital skills during major and/or rapid equipment and software upgrades or other changes, assuming limited formal training support.

**DESCRIPTION:** The Army is going digital. Currently, digitization is focused on a few units, such as the 4 ID, or in a few career fields, such as Intelligence. Digitization is being carried out through Advanced Warfighting Experiments (AWE) and equipment upgrades. Things are not always going smoothly. By 2010, the Army Experimentation Campaign Plan would field fully digitized light infantry, strike force, and heavy units. A lot of money will be put into a lot of digital systems to bring the transformation of the Army about. Equipment will be fielded, at times, with advance notice, with mobile training teams, and at a measured pace. At other times, digital equipment, software, and doctrine changes may come in rapid bursts, with little formal training support for them. The Army needs soldiers to be able to adapt readily to maintain and upgrade their digital skills, when the equipment and software they use change or other aspects of their jobs change such that they can no longer fully utilize their digital systems. For example, soldiers may be assigned to environments such as peacekeeping deployments in which their normal equipment and software may not be available or useable, or only different digital versions of the equipment and software are available. Therefore, it is difficult to retain or update their digital skills in a standard or orderly manner. These kinds of problems are particularly acute in branches such as Intelligence that are at the forefront of digitization. Strategies and techniques are needed that reduce the period of decrement in performance resulting from the introduction of new equipment and/or software, including when there has been a gap in use by a soldier of the previous "old system." Soldiers need strategies and techniques to help them adapt quickly to the constant changes and move forward. One dimension of interest is the generality-specificity of the digital skill training. This dimension can be reflected in a training emphasis on general digital skill building compared to an emphasis on particular digital tasks or equipment/software skills. The dimension can also be reflected in its sequencing; for example, it may be optimal in the early stages of training to focus on general principles and analytic components of jobs and then later focus on procedures specific to the current digital equipment and software, or it may be more effective to focus on both at the same time. Another dimension is the location for training the digital skills. Training can take place in Army schools, on-the-job, on a soldier's own time, as an embedded feature of new equipment/software, or in combinations, although this dimension is complicated by the extremely high optempo and long duty hours in some units, which would prevent some training sites or means from being effective. Finally, there is an interest in the dimension of learning strategy. For example, adaptability may be enhanced by allowing soldiers the time to play with their new equipment/software (exploratory learning). Alternately, adaptability may be enhanced through the use of mentors or master trainers that can provide a holistic perspective that facilitates adaptability. Or adaptability may best be gained by some special structuring of how the digital system changes are presented. It is expected that the winner of this project will determine how to facilitate the adaptability of digital skills, and verify recommended strategies and techniques in a training and/or operational situation.

**PHASE I:** Identify an innovative package of strategies and techniques that should prove effective for training adaptability in digital skills. Develop a method(s) to determine how to minimize interim performance decrements while digital skills are being upgraded. Describe and design research for verifying the strategies and techniques for the optimal training of adaptability and the criteria for assessing training success.

**PHASE II:** Verify the training strategies and techniques in a training and/or operational situation(s). Incorporate results into a written set of training techniques, strategies, guidelines, and recommendations, in a format easy to include in appropriate Army training material.

**PHASE III DUAL USE APPLICATIONS:** The same difficulties that soldiers are encountering due to frequent changes in equipment and/or software, including possible discontinuities in usage of old systems, are found with civilian workers in the many environments that now routinely depend on digital equipment. Most validated principles, strategies, technologies, and techniques that work in the Army are likely to be easily transformed for commercial use in the civilian sector and would be readily received.

**OPERATING AND SUPPORT COST (OSCR) REDUCTION:** The successful application of research results should save direct costs by decreasing the amount of time and training support needed in training a specific set of skills for a specific set of tasks and equipment as well as costs of refresher training.

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2. Salter, M. S. & Black, B. A. (1998). Back-up training requirements for the digitized battlefield: An overview (Study Report 98-05). Fort Knox, KY: U.S. Army Research Institute for the Behavioral and Social Sciences.
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**KEYWORDS :** digital skills training, computer skills, skills retention, skill transfer, adaptability

## **U.S. Army Research Laboratory (ARL)**

A99-111                      TITLE: Micromagnetic Sensor Technology

**TECHNOLOGY AREAS:** Sensors, Electronics, and Battlespace Environment

**OBJECTIVE:** Develop technology for networks of magnetic microsensors

**DESCRIPTION:** We are seeking to develop technology for small, low-power, low-cost sensors to detect magnetic fields in the battlefield generated by the presence and movement of armed troops, tracked and wheeled vehicles. It is anticipated that these sensors may be part of a network of battlefield microsensors which employ a variety of sensor technologies (which may also include, but are not limited to: acoustic, seismic, IR, etc.). Such networks, when linked to indirect fire (e.g., from artillery) may help obviate the need for conventional landmines, although other conceivable roles also exist. The focus is on sensors that can be fabricated by micro-electronics and micro-electromechanics (MEMS) techniques. This will allow integration of sensors with signal processing and transmission circuitry to allow rapid prototyping with very little capital investment by using the existing industrial base.

**PHASE I:** Research is needed in one or more of the following areas: (a) novel magnetic sensor concepts leading to quantification of detection distance(s) for various classes of targets; (b) filtering and/or signal processing techniques which are expected to improve the detectability of targets in a battlefield environment; and (c) computer-based modeling of targets and sensors that can provide a capability to perform trade-off analyses of sensor concepts during prototype design. The resulting sensor and signal processing circuitry in (a) and (b) must be capable of fabrication by microelectronics/MEMS techniques. The modeling in (c) must apply to these microsensors and associated circuitry.

**PHASE II:** Development of prototype hardware corresponding to the research conducted in Phase I; e.g.: (a) prototype sensors suitable for testing; (b) prototype filtering hardware demonstrating improved performance and/or micro-power requirements; (c) detailed modeling and analysis to support trade-off decisions during prototype development. **PHASE III:** Dual-use applications: It is anticipated that the research described above could also be applied to commercial networks of magnetic microsensors used to monitor urban or highway traffic, automated warehouses, and secure installations, perimeters, and borders.

**OPERATING AND SUPPORT COST REDUCTION (OSCR):** The "networked microsensors" concept represents a fundamental shift in the way we can view the battlefield, as compared to the high-cost, high-resolution, fixed sensors which are often employed today. By definition, these sensors must have very low cost, to the point that they can be remotely deployed in large networks and never recovered. They will require no external power, no spare parts, and no maintenance.

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KEYWORDS: Magnetic, Microsensors, Anomaly Detection, Unattended Ground Sensors

A99-112 TITLE: Logistics Site Planning and Operation Tool (LOGSPOT)

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Design and program an inexpensive PC based software package that logistics commanders and their staffs at all levels can intuitively use to optimize the layout of their logistics sites and plan daily operations.

DESCRIPTION: At the tactical level, the Army currently has no planning tool to assist logistics commanders and their staffs in site planning, layout, and logistics and tactical operations. Logistics commanders and their staffs at all tactical levels must rely on paper maps, plastic overlays and grease pencils to plan and display the physical location and layout of their units. This process is man-hour intensive and prone to inefficiencies and errors, causing delays and losses in supplies and logistics support. Logistics planners and operators need a tool that will aid them in optimizing the layout and operation of their logistics units. This Logistics Site Planning and Operations Tool (LOGSPOT) would allow logistics planners to optimally place logistics support equipment, defensive weapons and supply locations into the positions based on terrain considerations, customers requirements, logistics operating rules, safety and enemy threat. LOGSPOT would be networkable allowing logistics data to be transmitted, integrated and displayed on LOGSPOT systems at higher levels of command. Networking would allow shipping and transportation data to be transmitted for use in daily unit operations planning. LOGSPOT would use this information to optimize the storage and transloading of supplies based on supply arrival times and customer demands. LOGSPOT would be intuitive for operators (Sergeants to Captains) to use. LOGSPOT would be used on any Pentium based laptop with a modem. Maps, logistics information and unit displays would be easy to understand by intended users.

PHASE I Develop a detailed system design that specifies the tool's conceptual design, human computer interface design, logistics data import and export methods, and logistics and tactical data and display representation. The contractor's design should demonstrate how commanders and their staffs would use LOGSPOT in a field environment. Designs must cover: (1) Entering and displaying unit equipment and defensive positions on a computer generated map. (2) Use of map terrain information and logistics rule sets in planning and optimizing unit set-up and operations and (3) Passing logistics and defensive set-up information to higher and lower command levels. Contractors should concentrate on delivering a design that is easy to use without extensive training. Interfaces should be intuitive to use for both military and commercial logisticians.

PHASE II Develops and demonstrates a prototype system based on Phase I approved designs. Demonstrations will be conducted in a realistic environment. Conduct testing to prove feasibility and usefulness and potential benefits of LOGSPOT.

PHASE III DUAL USE APPLICATIONS: Automated commercial logistics tools have concentrated on the speeding up the logistics pipelines. LOGSPOT is unique in that it concentrates on optimizing the nodes along the logistics pipeline. Commercial uses of the LOGSPOT would focus on logistics site operations and the benefits of an optimized site for conducting daily logistics operations. Commercial interest would come from the potential cost savings from increased optimization of these storage sites, transportation hubs, manufacturing sites and construction projects.

OPERATING AND SUPPORT COST REDUCTION (OSCR): LOGSPOT seeks to aid in OSCR by reducing lost and frustrated supplies, reducing delays inside logistics nodes, and reducing the number of man-hours needed to plan logistics operations.

KEYWORDS: Logistics, operations planning, site layout, Combat Service Support.

A99-113 TITLE: Novel Wear Resistant and Thermally Insulative Materials

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVES: Development of a novel functionally graded material (FGM) that is both wear resistant and thermally insulating.

DESCRIPTION: Anticipated future diesel engines will require higher power output and reduced engine volume while simultaneously increasing fuel efficiency and decreasing emissions. Since the 1970's efforts to develop low heat rejection

adiabatic and minimum friction engines for military use have been underway.<sup>1-3</sup> The objectives for these engines was to reduce combat failures associated with the loss of engine coolants or liquid lubricants. Monolithic ceramics and ceramic-based thermal barrier coatings (TBCs) have been the candidate materials to achieve these objectives.<sup>4-6</sup> Functionally graded materials (FGMs) have been studied in recent years with the focus of optimizing thermal or wear resistant properties, but not both. Only lately, has the "science" of FGMs and the development of manufacturing processes for the production of FGMs reached a mature stage where this novel concept might be possible. Two factors have been particularly significant in advancement of FGMs: (1) development of higher purity and quality starting materials, (2) development of new processing techniques. This novel FGM would allow engineers to design engine componentry (i.e. pistons, piston rings, valves and cylinder liners) that would be both insulating and wear resistant, thus increasing overall engine performance and efficiency to meet the needs of Crusader, Future Combat Systems and AAN requirements.

PHASE I: Identify and demonstrate the feasibility of FGM material(s) to meet or exceed the wear resistance properties of 4140 steel, and have a thermal conductivity  $\leq 12$  W/mEK. Also this material must meet a minimum thermal shock resistance of 25 cycles of RT to 600EC, at 30-minute intervals between cycles, without material delamination or spallation.

PHASE II: Exploit and improve the wear and thermal properties of the Phase I material, and demonstrate the feasibility of the material processing by applying it to geometrical configurations which are representative of the appropriate reciprocating engine components.

PHASE III: Dual-Use Applications: The performance of the material shall be demonstrated by applying the material to appropriate reciprocating engine components and testing these components using a single- or multi-cylinder engine with operating conditions similar to high output military engines. Army and automotive industry requirements for increased power density, efficiency, and lower heat rejection would benefit from the material developed in this program.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Any development of a novel materials and associated processing, that could produce a wear resistant, thermally insulating material will extend the service life of diesel engines and enhance combat force survivability. Experimental confirmation that a wear resistant and thermal insulating material results in improve engine performance may lead to reductions in engine size and weight with an associated reduction in armor. This would also, improve logistics (materiel deployability, increased range, reduced maintenance) and improve survivability (increases in speed, range and maneuverability).

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KEYWORDS: Thermal barrier coating, functionally graded materials, wear resistance, thermal insulation

A99-114 TITLE: Smart Materials for Collapsible Fuel and Water Storage Tanks

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Design, synthesize and manufacture new and improved materials capable of being used as collapsible fuel and water storage tanks. The material must have excellent thermal, oxidative, UV and hydrolytic stability, resistant to water, solvents and various fuel types as well as possess the necessary mechanical strength to hold up to 210,000 gallons of fuel or water. Additionally, the material must possess the ability to sense and alert personnel as to the onset of material failure.

DESCRIPTION: The need for the new, smart materials was facilitated by events occurring in Saudi Arabia, where collapsible fuel storage tanks failed while in service. The fuel tanks were normally exposed to intense sunlight as well as air temperatures

exceeding 130 F, this caused catastrophic failure due to seam splitting, where bond lines could not withstand the unique climate conditions and leakage occurred. All the failed fuel tanks were constructed of nylon fabric coated with polyurethane where the tank seams were heat sealed and were only in service for as little as 2 months. The Army is interested in the development of new smart materials that will meet and, if possible, exceed the requirements set forth above. In addition, the materials should withstand a variety of temperatures from -60 F to 160 F and remain stable to UV degradation. The material of interest should be a smart material; i.e., have the capability to detect material/bond line deterioration from hydrolysis by release of a chemical dye or other sensor to alert personnel of possible problems.

PHASE I: Demonstrate the feasibility of developing new materials with improved mechanical strength, excellent bond line strength and excellent thermal and oxidative stability with the capability of being used as a collapsible storage tank for fuel and water under all climate conditions. The material should incorporate some sensing capability to determine the onset of possible failure.

PHASE II: Design, synthesize and manufacture an optimized collapsible fuel storage tank prototype based on material(s) developed under Phase I effort. Demonstrate the scale-up capability of the proposed material for fabricating end item collapsible fuel and water storage tanks.

PHASE III DUAL USE APPLICATIONS: Successful completion of this work would have several applications in the commercial marketplace. The areas of tarps and tents, baggage, service station gas tank liners, oil recycling containers and water storage containers. Chemical storage and transport, spill recovery, commercial airline refueling stations would be affected.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Potential life cycle cost savings for the Army will be achieved due to enhanced durability and reliability of end product storage tanks. Currently, these fuel tanks are used by the Air Force, the Army and the Marines who all have exhibited seam failure in the past. The enhanced material will increase the service life of the tank, thus affording a reduction in the quantities required. The dual use characteristic will increase the military's response to surge demands while still allowing a reduction in inventory and reduced logistics of managing multiple NSNs, specifications and technical publications. Decrease in procurement cost by structuring a single contract for dual use tanks instead of multiple contracts for fuel and water tanks. Potential for increased cost avoidance in the area of environmental clean-up and adverse legal action.

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3. MIL-T-52983 Tank Fabric, Collapsible, 3,000, 10,000, 20,000 and 50,000 Gallon, Petroleum

B. Reports & Papers on Fuel Tank Materials & Deterioration

1. "Failure Mechanism of Urethane Elastomer Coated Fabric Collapsible Fuel Tanks", Henry O. Feuer and Paul Touchet; US Army Belvoir RD&E Center Technical Report No. 2488, dated March, 1990.
2. "Extending The Service Life of Urethane Tanks", P. Touchet, P. E. Gatz, H. O. Feuer and A. R. Teets, US Army Belvoir RD&E Center Technical Report No. 2519 dated March 1992
3. "Effects of Extracting Hydrolytic Stabilizers on Urethane Performance", paper presented at 138th ACS Rubber Division Meeting in Washington DC, Oct 1990 and also published in the April, 1991 issue of Coated Fabrics magazine.

KEYWORDS: Collapsible storage tank, polyurethane

A99-115

TITLE: Low-cost, Adhesiveless Method for Assembling Fibrous Preforms

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Preform assembly is the single most costly step in the fabrication of fiber-reinforced polymer composites. The objective is to develop and demonstrate an inherently inexpensive and effective means for connecting the individual preform plies so that a desired preform shape is achieved without the use of tacifiers or expensive stitching.

DESCRIPTION: Making composites more affordable is not only an Army need but a pervasive DoD technical goal. The Army, for example, is aggressively pursuing these objectives in the "Rotary Wing Structures Technology Demonstration" Program (RWSTD) and the "Knowledge and Process Tools for Manufacturing of Affordable Composite Structures" Program (a MANTECH-sponsored Manufacturing Technology Objective (MTO)). Similarly, the Composites Affordability Initiative (CAI) is a Defense Technology Objective (DTO) with Air Force, Navy, and Army participation [1]. Preform technology is fundamental to the development of advanced composite structures, particularly those capitalizing on recent advances in resin

infusion processes such as VARTM (Vacuum Assisted Resin Transfer Molding) [2,3]. Nevertheless, preform fabrication procedures remain by far the single most expensive and labor intensive element of a given composite manufacturing operation [4]. While advances in stitching and automation have begun to address this issue, relatively little innovation has been applied to the fundamental problem of connecting one ply to another in the "build up" of the preform geometry and part thickness. Currently manufacturers use polymer-based adhesive tacifiers, but recent evidence indicates adhesives interfere with both the resin flow and ultimate mechanical properties [5]. Traditional stitching is expensive and difficult to justify in many applications. A novel, inexpensive, easy to implement method for connecting successive plies is required which is amenable to both manual and automated implementation. The manual use of the method is emphasized given that, in some cases, hand lay up is still the preferred and more economical method for producing a composite system [4,6,7]. The technical goal is to develop a generalized means for mechanically fastening one ply to another, and ensuring that both the material and technique used to accomplish this assembly do not appreciably interfere with either the resin flow or mechanical properties developed in the composite.

PHASE I: Design and develop a novel method for inexpensively and effectively connecting successive woven fibrous plies to fabricate a preform that does not use adhesives or tacifying agents. The method should be amenable to either manual (i.e., hand held) or automated (e.g., robotic) implementation. Demonstrate the ability to "build up" a complex preform geometry that does not distort or allow excessive ply slippage prior to or during impregnation and/or curing.

PHASE II: Refine and scale up the novel assembly technique developed during in Phase I. Particular emphasis should be on producing thick (e.g., >1") glass laminates for use in Army ground vehicle, shelter, and armor materiel. Scale up will successfully demonstrate a minimum 30% reduction in preform assembly cycle time. Integrate method with automated preform fabrication system.

PHASE III DUAL USE APPLICATIONS: The successful development of a low cost preform assembly method has vast and significant implications, both in the commercial and DoD sectors, given that affordability issues are currently limiting more pervasive adoption of polymer composite materials. Preform technology has been cited as the largest source of cost in the overall production of both commercial and military composite products [ref. 4]. Successful and innovative preform assembly techniques would directly impact these issues, accelerating a host of improved composite applications including infrastructure, commercial transportation, building materials, and storage systems.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The significant weight reduction offered by polymer composites translates directly into reduced operation costs through increased fuel efficiency and/or operational range. Furthermore, polymer composites exhibit dramatic corrosion and environmental integrity, reducing the need for frequent replacement and maintenance during the service life of a given structure, component or vehicle. Finally, a more economic and cost effective preform assembly technique will require less material and supplies during repair operations.

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KEYWORDS: Preform, preform assembly, polymer composites, thick section laminants

A99-116 TITLE: High-mobility Trailer

TECHNOLOGY AREAS: Ground and Sea Vehicles

OBJECTIVE: Develop and validate the technology for future high-mobility trailers compatible with the mobility requirements of Army After Next (AAN).

DESCRIPTION: The efficient movement of materiel in war is increasingly important for AAN. Future military wheel vehicles will traverse rough terrain in excess of 50 mph with an occupant absorbed power of less than 4 watts for terrain having a surface roughness of 3 in. rms. These vehicles will have highway dash speeds approaching 100 mph. Conventional trailers

mechanically linked to tow vehicles are incompatible with the high-speed rough-terrain mobility needs of AAN and could cause serious accidents when operated under these extreme mobility conditions. It is anticipated future trailers will have onboard propulsion, active suspension, and energy storage systems as well as vehicle speed and directional controls. The self-propelled trailer is electrically linked through an umbilical(s) to the tow vehicle creating a convoy like arrangement. It is anticipated that future trailers will not have mechanical connections between the trailer and the "tow" vehicle. Future AAN wheel vehicles will probably have hybrid electric drives. Excess electrical power from the "tow" vehicle as well as terrain information is passed between the tow vehicle and the trailer. This umbilical attachment between vehicles affords considerable flexibility in transporting materiel. For example, multiple small tow vehicles could be linked together to supply power to a much larger trailer or multiple trailers. Only the lead tow vehicle needs to be manned because the subsequent tow vehicles would be operating in a trailer mode except for their power generation. Because the tow vehicles are hybrid electric drives and makes extensive use of computers for controls, virtually any AAN wheel vehicle could be a tow vehicle. The size of the trailer for this project should be approximately 180 inches in length by 84 inches wide. The trailer should be a flat bed configuration that will accommodate either a container for solid cargo or a tank for liquid cargo. The height of the container/tank exclusive of the trailer should not exceed 60 inches. For demonstration purposes the center of gravity of the container/tank and cargo shall be approximately 50 percent of the container/tank's height. Cargo weight including the weight of the container/tank should be approximately 4000 pounds. The trailer shall have 4, 6 or 8 suspension-wheel assemblies. All of the suspension-wheel assemblies shall be identical. Suspension systems will be actively controlled to reduce the dynamic automotive loads and facilitate mobility across rough terrain. Inwheel electric motors shall be used throughout for propulsion. When driven across rough terrain at 50 mph the cargo shall not experience more than 8 watts of absorbed power. This trailer shall not have a conventional mechanical link to the tow vehicle. Furthermore, the trailer shall have an umbilical cable(s) to the tow vehicle to transfer power and terrain information.

PHASE I: Develop a high-mobility trailer concept compatible with future AAN mobility requirements. Develop a preliminary design of the trailer that will be built in Phase II. Demonstrate the trailer concept using kinematics simulation software such as CADSI's DADS computer code or a similar kinematics simulation software package. Through simulation define the operational limits of the trailer. Describe in depth the logic used to convoy the tow and trailer vehicles.

PHASE II: Design, fabricate and conduct a 200 hour endurance test of the high-mobility trailer with high center of gravity solid and liquid cargo. The trailer, all design information, test results, and simulation will be deliverables in this program.

PHASE III DUAL USE APPLICATIONS: There is an expanding market for high mobility recreational and commercial vehicles. Oil exploration, electrical power, fire fighting and search and rescue, to name a few, require the movement of men and equipment to remote locations that frequently utilizes helicopters. Frequently, this movement of men and equipment requires speed such as experienced in the fighting of forest fires in California and Florida. Helicopter lease costs are between \$600 and \$2000 per hour and their availability can be limited in times of emergencies. Also, helicopters are frequently ineffective in the delivery of men and equipment to dense forest or mountainous regions. Once men and equipment are delivered local transportation is still needed requiring additional expensive helicopter time. High mobility trailers will greatly lessen the dependence on helicopters and will facilitate the movement of more material to remote locations in less time having a positive affect on operational costs. Mobility of sport utility vehicles have also caused an increased interest in vacationing in areas other than the trailer parks we call camp grounds. Families are willing to spend more of their discretionary dollars to "get away from it". When they get away from it they will need a trailer with high mobility. The only off road excursion that today's family trailers are designed for is the trip from the driveway to the backyard. Therefore, the technology developed in this program should be equally applicable to commercial, recreational and military interests. Once matured the commercial and recreational markets should drive future technology advancements for the military further reducing the cost of mobility for the military.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The development of high mobility vehicles will result in quicker response at a lower operating cost by the Army to the movement of men and materiel and is consistent with the needs of AAN. Without this capability the soldier's movement could be severely constrained by the slowest element of ground vehicles, the conventional trailer.

KEYWORDS: High-mobility, trailer, active suspension, hybrid electric drive, Army After Next.

A99-117 TITLE: Energetic Materials for Batteries and Electrochemical Capacitors

TECHNOLOGY AREAS: Information Systems Technology; Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Synthesize/identify new materials and chemistries for electrochemical power sources for communications, munitions, vehicles and other Army applications



DESCRIPTION: 1) Primary Batteries are needed to power a large variety of electronic and small electrical equipment over the full military temperature range (-40o to 70o C) with a minimum of performance degradation after storage for one year at 30o C or after one month at 70o C. The baseline technology for this purpose is Li/SO<sub>2</sub>, which provides specific energy and power greater than 160 Wh/kg and 40 W/kg, respectively. A more energetic and benign lithium battery chemistry with higher potential for dual use is desired. Possibilities include the synthesis and use of novel high-energy positive plate materials (e.g., various forms of manganese dioxide) and of compatible liquid, polymeric or polymer-matrix electrolytes. Particularly of interest, is the development of a battery chemistry, which would allow soft packaging, thereby increasing energy density by as much as 50%. This implies a cathode material that is not chemically aggressive to organic electrolytes, an electrolyte which is highly resistant to oxidation and reduction and/or an internal mechanism for eliminating gases produced during cell storage. 2) Rechargeable Batteries - Improved Li-Ion or Li battery chemistries are being sought for applications similar to those mentioned above. The baseline chemistry is now Li-Ion/liquid electrolyte/Li<sub>x</sub>CoO<sub>2</sub>, which can provide specific energy and power of approximately 100 Wh/kg and 40 W/kg respectively and over 100 deep cycles. Improvements are needed in low temperature performance (present limit is approximately -10o C), energy and power densities. Improvements might be gained through the synthesis of more energetic electrode materials and new liquid, polymeric or polymer-matrix electrolytes. Concepts to allow soft packaging (as discussed in section 1, above) are also being sought here. 3) Reserve Batteries are needed for munition applications where battery shelf life of up to 20 years is required. Both thermal and liquid reserve batteries are in use today. These provide only a small fraction of the intrinsic energy of the battery couples, because of the space allotted to caloric materials/insulation (thermal batteries) or to mechanical parts which serve to contain the electrolyte and release/distribute it under impact-spin conditions (liquid reserve batteries). Power density requirements are greater than 100 W/l. Reserve batteries are overly expensive because of their mechanical complexity. That complexity also causes great difficulty in developing smaller batteries for newly emerging applications. Approaches to achieving improved specific energy and reduced cost/complexity might include: a) The development of an "active" battery chemistry with a shelf life greater than 10 years. The use of relatively expensive, high purity materials is permissible. b) The development of novel activation methods. Such methods would release a highly conducting electrolyte within milliseconds after gun launch with 15,000 to 30,000 g's setback and 45-500 rps spin. The methods could include phase change, the use of a container material which pulverizes on impact, the use of frangible microencapsulated electrolyte, etc. The activation method must not operate if the battery is dropped from a height of 2 meters to a hard surface. 4) Electrochemical Capacitors are required for burst communications and for vehicular applications. Low cost, high cycle life, high power and high energy densities and operation over most of the military temperature range are requirements. The baseline low-cost chemistry utilizes carbon electrodes and a liquid organic electrolyte. Energy and power densities of approximately 4Wh/kg and 1 kW/kg appear to be at hand. Even higher energy densities are required and could result from the discovery of more capacitive (including pseudocapacitive) electrode materials, higher voltage electrolytes and improved methods for preparing electrodes with high electronic conduction and more effective electrolyte/electrode interfaces.

PHASE I: Phase I should result in the identification/synthesis of at least one of the major cell components for a chemistry which could provide performance exceeding the present state-of-art.

PHASE II: Phase II will provide for further exploration of cell components and for the formulation and demonstration of a complete prototype cell or battery.

PHASE III DUAL-USE APPLICATIONS: The energy storage components under consideration here are of great potential value for use with cellular phones, laptop computers, camcorders, many other commercial electronic equipment and for civilian electric-drive vehicles.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The new primary batteries (for use in combat) being sought are to be "dual use" as compared with present Li/SO<sub>2</sub> primaries which are not. The commercial base is expected to foster competition and reduced costs. The new rechargeable batteries (to be used mainly for training) could provide power for a fraction of the operating cost of primary batteries. The substitution of active for reserve batteries could provide power for smart munitions applications at a fraction of the cost of the latter power source.

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4. S.P. Ding, K. Xu and T.R. Jow, "Comparison of Properties of a Symmetric and Asymmetric Tetraalkylammonium Salt and Their Nonaqueous Electrolytes", Proc. Of the 194th Electrochemical Society Meeting, Boston, MA. 1998

KEYWORDS: Batteries, capacitors, reserve batteries, anodes, cathodes, electrolytes

## TECHNOLOGY AREAS: Biomedical

**OBJECTIVE:** Develop lightweight, inexpensive, and reusable personal sampling sensors for real-time or quasi-real-time monitoring of hazardous gaseous combustion/pyrolysis chemicals for use in a fire/thermal/smoke environment. New and innovative technologies are sought, such as optical system-on-a-chip technology, but any viable technology is acceptable. Such personal sampling sensors should collect desired information rapidly and reliably, and interface easily with both real-time display devices and data storage devices. Described sensors must be able to be easily placed on clothing or protective clothing items. Personal monitoring sensors should have chemical specific selectivity detection capability on the order of parts per billion by volume (ppbv), should exhibit rapid detection, should be fire/thermal/smoke resistant in their construction and must be capable of sampling effectively in a fire/thermal/smoke complex chemical gaseous environment. Additionally, the sensor should be reusable (a reversible system). Sampling parameters should include chemical species identification, peak concentration, and time-concentration history output. We are interested in both retrievable and remotely monitored personal monitoring sensors.

**DESCRIPTION:** There is a growing need for sophisticated lightweight, inexpensive, reusable personal sampling sensors for real-time or quasi-real-time monitoring of toxic parent chemicals and their pyrolysis products in hazardous or potentially hazardous environments. Personal sampling monitoring of this type will enhance our current capabilities to characterize hazardous environments and support the Army's critical mission of soldier survivability. Specifically, such sensors would enable the acquisition of critical research data needed to identify and quantify chemical insult hazards, under various combat conditions and circumstances; and directly foster the development of algorithms, models, and methodologies involving development of injury criteria and resulting estimates of injury impairment, performance degradation and soldier survivability, both in terms of potential operational and medical casualties. Successful development of these chemical sensors will enable exploitation of current Army vulnerability/lethality testing and associated controlled laboratory experiments, as well as make possible use of tri-service research efforts. For example, such sensors may enhance our capabilities to support analyses related to crew casualty assessment conducted as part of congressionally-mandated Army Live-Fire Testing to assess the vulnerability and lethality of weapon systems (combat ground vehicles and air system vehicles). Army Live-Fire testing directly promotes the development of improved military platform engineering designs that minimize crew member vulnerability and increase soldier survivability. Toxic gas combustion products and other fire-related gaseous chemicals of military interest, such as oxygen to investigate oxygen depletion, include: CO, CO<sub>2</sub>, O<sub>2</sub>, O<sub>3</sub>, NO, NO<sub>2</sub>, NH<sub>3</sub>, HCL, HFI, HBr, HCN, SO, SO<sub>2</sub>, acrolein, formaldehyde and acetaldehyde, and benzene.

**PHASE I:** Produce and demonstrate the capability of prototype components for such Personal sampling sensors for several of the chemicals of military interest (listed above) from existing or novel materials, capable of demonstrating the proof-of-principle.

**PHASE II:** Demonstrate the features and capabilities of pre-production prototype shirt pocket size personal monitoring sampling sensor system for all seventeen chemicals/combustion/pyrolysis products of military interest (listed above). Conduct, present and document sound scientific testing on personal monitoring sampling sensors for each chemical of interest, including testing in fire/thermal/smoke environments, while simultaneously characterizing the test environment and identification of concentration of chemicals present using other standard and accepted practice methods and procedures to evaluate personal monitor sampling sensor effectiveness and utility.

**PHASE III DUAL-USE APPLICATIONS:** The use of such sampling sensors is anticipated not only in basic and applied research involving development of algorithms, model, methodologies, and criteria supporting Army soldier survivability, but also in Army Test & Evaluation, such as in Department of Army Live Fire Testing of full-up combat ready vehicle systems, or related controlled experiments or laboratory testing, and in other DOD Live Fire Testing and Evaluation. For example, such sensors may be of interest and have practical application to other Army test and evaluation agencies, such as the U.S. Army Test and Evaluation Command (TECOM), the Aberdeen Test Center (ATC), and the U.S. Army Operational Test & Evaluation Command (OPTEC). Such sensors may have utility in important projects involving the study of fire and combustion gases and their control, such as the HALON 1301 replacement projects. Other DOD and Non-DOD agencies involved with fire and combustion chemicals prevention and control may have applications for such sensors in their research, and test & evaluation (e.g., Walter Reed Army Institute of Research (WRAIR)- toxicology of parent and combustion gases and respiratory research; U.S. Air Force-air crew protection and survivability research; U.S. Navy-ship and submarine onboard fires; and National Aeronautic and Space Administration (NASA)- flight and space vehicle fire prevention and control). Personal monitoring sensors for combustion gases would have both occupational and environmental applications. For example, although combustion gases are known to be a serious threat in several civilian occupations (i.e., firefighting), there is a

paucity of useful exposure data. Such personal monitoring sampling sensors would have immediate applications in a variety of civilian emergency response and occupational environment monitoring or related research, including: firefighting, hazardous material response, hazardous material workers, industrial safety workers (e.g., coal miners, steel workers, etc.), and industrial confined space monitoring associated with many occupations (e.g., industrial chemical manufacturing). Environmental applications would include both qualitative and quantitative indoor and outdoor air sampling and monitoring, regulatory standard compliance, and epidemiological exposure assessment in environmental hygiene studies.

**OPERATING AND SUPPORT COST (OSCR) REDUCTION:** This technology area has the potential to improve OSCR in several areas. For example, development of improved algorithms, models, and methodologies involving development of injury criteria and resulting estimates of injury impairment, performance degradation, and soldier survivability potential may lead to development of improved soldier protection systems, improved crew safety, improved/better survivability of combat systems and reduction in combat crew operational casualties, as well as potential reduction of medical casualties. The use of reusable personal monitoring sampling sensors will result in significant cost savings in the area of research, test and evaluation.

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**KEYWORDS:** Toxic chemicals, Pyrolysis/combustion products, personal sampling monitor, chemical sensors

A99-119                      **TITLE:** Low-cost Fabrication Technologies to Produce Transparent Armor Ceramics

**TECHNOLOGY AREAS:** Materials/Processes

**OBJECTIVE:** To develop a cost effective method of producing transparent armor ceramics that will enable the weight of the transparent armor systems to be reduced by at least 35% against armor piercing (AP) threats relative to present glass plastic transparent armor systems.

**DESCRIPTION:** There is a critical need to reduce the weight and thickness of armor on current and future military ground and air vehicles. Future requirements call for increased levels of protection; lighter weight, reduced thickness, and increased survivability. Transparent armors currently in use consist of soda-lime glass or borosilicate glass laminated to polycarbonate. It has been demonstrated that by using advanced transparent ceramics such as aluminum oxynitride spinel (ALON), Mg spinel, or single crystal sapphire in transparent armor systems, the areal density required to defeat small caliber AP projectiles can be reduced by 35 % to 60 % compared to traditional glass-plastic systems. Two factors have kept these materials from being used in transparent armor systems. The cost of the materials is too high and they cannot be produced in the large sizes needed. The purpose of this SBIR is to develop substantially lower cost processing routes for producing transparent armor ceramics that will reduce the weight of transparent armor systems by at least 35 %. The processes developed must be capable of producing ceramic plates at least 36" in diameter, between 0.25 inch and 1.00 inch.

**PHASE I:** The submitted proposal will include the selection of a armor material and a single fabrication technique to be investigated. In phase I, the proposer will demonstrate the feasibility of producing the material, as specified in the proposal. The technical and economic advantages of the fabrication route, material chosen and ability to be scaled up to produce (24" x 24" x 0.5") will establish the basis for the Phase II proposal.

**PHASE II:** Scale up of the production method developed in Phase I to demonstrate cost effective fabrication of panels 24 in. x 24 in. x 0.5 in. thick. Evaluate and optimize the ballistic performance of the material developed against a specified AP threat. Measure the strength, thermal expansion, thermal conductivity as well as the transmittance in the visual and Infra-red spectrums. Perform a cost analysis to determine the production costs for 100 panels per annum via the chosen fabrication route.

**PHASE III DUAL USE APPLICATIONS:** The successful development of a low-cost fabrication technology for a transparent ceramic that increases the performance of transparent armor systems would be of great benefit to both military and commercial armor/security systems. Many of the transparent ceramics that have demonstrated they can greatly improve the performance of transparent armor systems are also of interest for Infra-Red, and dual band windows and domes that transmit wavelengths between 3 microns and 5.5 microns. The next generation of dome materials for high speed missiles will require high strength, thermal conductivity, and low thermal expansion up to 1000EC. The ideal material will be transparent to

electromagnetic radiation of 3 micron to 5.5 micron wavelengths, exhibit low emissivity, scattering and birefringence, and should be resistant to rain erosion at supersonic speeds. If a material can be used both for transparent armor and IR window and domes, it is expected that the economies of scale will drive down the costs of the material and benefit both armor and IR domes. Non military uses include protection for law enforcement personnel, armored cars and bank security.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: A lighter weight armor will reduce operating costs through better fuel mileage and increase the usable payload for armored vehicles.

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KEYWORDS: Armor, Transparent Armor, Ceramic armor, spinel, ALON, sapphire

A99-120 TITLE: Compact, High-power Microwave Antenna

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: The objective is the development of a high power microwave antenna with reduced size and weight for tactical radio frequency directed energy (RF DEW) applications. The desired characteristics are:

Weight:	<250kg
Cross-sectional Area:	<7 square meters deployed
Largest side dimension:	<1.2m deployed
Gain:	>30dB.
Frequency:	L-band
Bandwidth:	>10%
Power:	>100MW
Pulse Width:	>5 microseconds
Pulse rep-rate:	> 100 hertz

The antenna will be fielded on standard Army land vehicles (e.g., HMMV) and air platforms (e.g., Blackhawk).

DESCRIPTION: The Army has a requirement for a mobile (air/land) high power microwave antenna system for RF Directed Energy Weapon applications. The antenna system must be low weight, highly portable, and be able to handle high pulsed power levels. The objectives are stated above. With recent advances in dielectric materials, ferroelectric materials, semiconductors and plasmas, coupled with advances in numerical and analytic prediction techniques, the Army is looking for a leap ahead in antenna technology to support the survivability and lethality requirements of the Army After Next (AAN).

PHASE I: The contractor will design an antenna using the state-of-the-art in component, material and plasma technology to meet the above objectives. Feasibility will be demonstrated through numerical and analytic studies supplemented by piece-part experiments.

PHASE II: The contractor will construct at least two prototypes for evaluation. The government will provide the L-band sources and the antenna range facilities. The contractor will characterize the prototypes. He will provide antenna gain patterns and experimentally determine power handling capabilities. The contractor will also supply preliminary designs for tactical field applications to include land and air applications.

PHASE III DUAL USE APPLICATIONS: The contractor will explore applications of the technology and features of his design for military and commercial fixed and mobile/transportable radar systems. He will also explore potential use in satellite and microwave line-of-sight communications.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: If successful the designs developed under this SBIR would be incorporated into a new suite of weapon systems. Cost advantages will be achieved by replacement or augmentation of existing weapon systems. Cost reduction is not quantifiable at this time.

REFERENCES: Jasik, H., Ed., Antenna Engineering Handbook, New York, McGraw-Hill, 1961

KEYWORDS: HPM,RF DEW,microwave,antenna,radar, information warfare

A99-121 TITLE: Wavelength Division Multiplexing Fiber Optic Microwave Delay System

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Research and develop a fiber optic system using wavelength division multiplexing techniques to delay pulsed and continuous wave microwave signals by intervals ranging from 0.5 to 30 milliseconds.

DESCRIPTION: Current fiber optic microwave delay systems are capable of delaying pulsed and continuous wave microwave signals up to about 0.5 milliseconds. In these systems, a microwave signal modulates a laser beam that is delayed in a programmable length fiber optic network and demodulated by an optical detector. A means of achieving much longer delays is required for advanced radar target simulation and electronic countermeasure generation. Wavelength division multiplexing makes it possible to establish several optical paths simultaneously at different light wavelengths through a single fiber optic path. Very long delays can then be realized by chaining multiple paths together. Technical goals for the proposed system are as follows: [1] Microwave signal delay: (a) Range: 0.5 to 30 milliseconds, digitally programmable in steps of 0.5 milliseconds; (b) Variation over operating frequency and temperature ranges: 10 nanoseconds; (c) Switching speed: <1 microsecond for any delay change; [2] Microwave signal characteristics: (a) Instantaneous operating frequency bandwidth: 8 GHz; (b) Input center frequency: 8 GHz; (c) Input signal level: 0 dbm; (d) System gain: 0 db nominal; (e) System gain variation over operating frequency and temperature range: less than +/- 3 db over entire operating frequency band and less than +/- 1 db over any 1 GHz segment of the operating frequency band; (f) Spurious products: -35 dbc or lower; [3] Built-in test functions: capable of assuring proper system functioning and identifying the source of major component malfunctions; [4] Operating temperature range: 0 to +50 C; [5] Operating power requirements: 115 VAC, 60Hz; [6] Physical: Mountable in a standard half-height rack and operable at 15,000 ft. above mean sea level.

PHASE I: Research, develop and propose a system design with the potential of realizing the goals in the description above, favoring proven technologies to minimize technical risk. Develop technical specifications for all system components and identify them as commercially available or to be developed. Conduct detailed theoretical and/or laboratory investigations on the design and performance of critical components to demonstrate the feasibility and practicality of the proposed system design, including mitigation of risks associated with factors limiting system performance. Deliver a report documenting the research and development effort along with a description of the proposed system and specifications for all system components.

PHASE II: Procure or develop the system component specified in Phase I. Fabricate the system proposed in Phase I. Characterize and refine the system performance in accordance with the goals stated in the description above. Deliver the prototype system along with a report documenting the system theory, design, component specifications, performance characterization and recommendations for system performance.

PHASE III DUAL-USE APPLICATIONS: The proposed research and development effort has wide commercial application to microwave signal processing functions in military and commercial radar sensors and communication systems. Military applications include radar target simulation and electronic countermeasure. Commercial applications include telecommunications, airborne and space systems, and sensor signal processing.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Cost savings of millions of dollars have been demonstrated using radar target simulators with microwave delay technology instead of targets. Development of the proposed system will be instrumental in extending these cost savings to other air and missile defense systems.

REFERENCES: Several articles related to the topic are found in the December 1998 issue of IEEE Communications Magazine, Vol. 36, No. 12. The whole issue is devoted to Multi-Wavelength Fiber Optic Communication. Titles of interest include: "Multi-Frequency Lasers and Applications in WDM Networks", "Multi-Wavelength Receivers for WDM Systems", and "Tunable Optical Filters for Dense WDM".

KEYWORDS: Laser,fiber optic,microwave,delay,wavelength division multiplexing

A99-122

TITLE: Time-efficient, Economical, High Rate Production and Manufacturing Methods for Nanoparticulates

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Conceive and develop processing and consolidation methods for nanoparticulates at large scale.

DESCRIPTION: The application of nanomaterials to structural applications requires that methods be developed to consolidate particulates to very high densities while preserving the nanoscale grain structure. In efforts to-date, attempts to consolidate nanoparticulates have been moderately successful. In research efforts, the sizes of consolidated nanoparticulate materials are limited to a few millimeters in extent while more commercial-like efforts have been limited to a few centimeters. These successes, although world leading, are modest when compared with the shape forming capability commonly found in other particulate fabrication sectors. Commercial development of structural components with nanomaterials as their basis will require the development of methods, equipment and techniques that greatly increase the scale at which consolidation is accomplished.

PHASE I: Identify the critical consolidation variables for the production of structural items utilizing nanomaterials. Identify fabrication methods that consolidate nanoparticulate materials to full density while maintaining the nanograin structure and controlling oxygen content. Demonstrate the processing method using a variety of materials to fabricate structural components no smaller than 500 cubic centimeters in volume. Methods developed shall be readily adaptable to production environments. Demonstrate the appropriateness of the materials and processing methods for the application(s). Deliver demonstration items produced with the materials, techniques, methods or procedures developed.

PHASE II: Work in Phase II should exploit the Phase I success, expand the range of materials and processes and begin to apply the methods developed to production-like situations. This work should highlight the generic nature of the developed process or method and deliver prototype or demonstration components. Process automation should be incorporated into this phase of the work. Demonstration parts should be fabricated that exceed 1500 cubic centimeters in volume. A fully functional prototype of equipment developed should be delivered. Testing in phase II should be suitable to demonstrate the benefits of the material or process developed and should include quasi-static and dynamic materials testing.

PHASE III DUAL USE APPLICATIONS: There are expected to be many near-term commercial applications for nanomaterials in densified form including tungsten-copper composites for thermal management, cermets and ceramics as cutting tools, bulk erosion resistant applications, and new transparent armors. Additional uses may be found in non-consolidated applications such as in the paint, drug, cosmetic and food industries. Reliable and accurate particle analysis is an important part of furthering and commercializing nanomaterial applications.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Cost reduction due to the use of more efficient materials for critical applications in survivability and lethality and reduced logistical burden.

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KEYWORDS: Nanomaterials, processing, automation, consolidation, scale-up

A99-123

TITLE: Direct Digital Synthesis Technology

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: The Army has a documented need for the development of enabling RF technologies that are both affordable and flexible with regard to their ability to address the Army's many radar and communication requirements. Transmitter architecture is one such technology area. For example, transmitter architecture could be reduced in terms of size, weight, power requirements, and cost if digital, highly complex wide-bandwidth waveforms were generated at the highest possible frequency instead of near baseband. These waveforms could be used for high-range resolution radar communication applications to sort targets from clutter that has a low probability of intercept.

DESCRIPTION: This topic seeks a direct digital synthesis (DDS) approach to reducing transmitter architecture complexity while improving the opportunity to pursue more multipurpose RF sensors. Goals of this work might be to operate at carrier frequencies of greater than 10 GHz and bandwidths of greater than 1 GHz. Another issue to be addressed is the spectral purity of the signals; a goal of greater than 60 dB over the modulation bandwidth is suggested. Waveform configurations should include chirp, step-frequency, phase-modulation, limited-impulse, pulsed-RF, and other hybrid modulations. Current limitations to achieving an optimal DDS technology include the following: > Low bandwidth clocks between 1 and 2 GHz limit ultimate bandwidths to the Nyquist criteria. > Alternative materials (e.g., Si-based) are needed to replace the high-power GaAs architectures. > Low intermediate frequency output (due to clock rates and architecture limitations) requires extensive hardware for microwave and millimeter-wave operations. > High spurious and phase-noise levels are such that they degrade system performance. > Lack of an integrated control for complex radar and high data rate communication functions.

PHASE I: This work should address emerging technologies that can meet the above goals with consideration of the stated limitations. A quality proposal would discuss a company's approach toward highly linear, ultra-fast digital/analog converters; integrated control and memory; and modularized construction (e.g., VME/VXI/PCI).

PHASE II: Design, build, test, deliver, and report on the chosen DDS approach. Performance and affordability should be the major emphasis of this effort.

PHASE III DUAL-USE COMMERCIALIZATION: A considerable commercial potential exists in both DoD and private-sector RF system applications: satellite-transmitted high-definition television, air traffic control and weather radar, as well many other wireless communication networks.

KEYWORDS: Direct Digital Synthesis, Digital Waveform Modulation, D/A Converters

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A99-124

TITLE: Real-time Image Restoration Processor

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop an inexpensive video processor capable of restoring distorted imagery (both visible and IR) that is often associated with "long-range" viewing, i.e., usually in excess of 1 km. The proposed restoration processor should be based on an algorithm that can accurately correct for atmospherically induced aberrations that are primarily due to optical turbulence and aerosol scattering.

DESCRIPTION: The amount of information conveyed by a highly magnified image of a distant object is often limited by adverse atmospheric conditions that serve to reduce both spatial resolution and image contrast. This is particularly true for optical paths close to the ground where refractive turbulence and light scattering due to haze is most severe. Although atmospheric aberrations affect all light either reflected or emitted, it is especially troublesome in the IR. Advanced IR imaging systems currently under development will not be limited by sensor characteristics, but by atmospheric degradation. It will be necessary to restore the original information content of the imagery to take full advantage of these "next-generation" sensors. Various post-processing algorithms are needed that are capable of restoring atmospheric degraded imagery. As an example, one such technique is based on a linear systems approach in which a predetermined atmospheric modulation transfer function (AMTF) is deconvolved, resulting in an enhanced "seeing" ability. Currently, there is a great deal of debate within the scientific community on which post-processing algorithm is of greatest value. In order to resolve this important issue, the authors would like prospective candidates to propose an optimal post-processing algorithm designed to mitigate atmospheric effects (based on cited research) and to develop a unique programmable video processing device that could be used to implement the necessary image restoration. The algorithm/device should have the following features; 1) be capable of restoring degraded video imagery in real time, 2) the device should be compact and relatively inexpensive to manufacture, and 3) the device should be easy to incorporate into existing visible and IR imaging systems, e.g., simply connect in-line between the video-out of the imager and the video-in of the display. The development of such a device should greatly improve the ability to resolve distant objects when viewed through the atmosphere and would likely represent a welcomed enhancement for both

military and civilian applications. Such applications might include, but are not limited to, remote sensing, surveillance/security observations, search and rescue operations, and conventional recreational videography.

**PHASE I:** Propose and design the image restoration algorithm/hardware including schematics that fully describe and identify all electrical circuits including the types of processors used for both mathematical computations and analog-to-digital conversion. Included should be a reasonable prediction of the anticipated performance characteristics of the device. The development of a prototype is desirable.

**PHASE II:** Assemble, test, and demonstrate a prototype device that should include all hardware and software necessary. An evaluation procedure will be conducted using degraded video imagery where various objective figures of merit are to be determined, e.g., point and line-spread functions will be measured before and after restoration.

**PHASE III DUAL USE APPLICATIONS:** Demonstration/evaluation of the final product will take place at an appropriate U.S. Army field test facility, and will include integration of the device with a third generation FLIR system currently under development. This device will be directly applicable to any long-range imaging system, e.g., visible, infrared, and millimeter-wave. Applications of this technology are numerous and include high resolution remote sensing, commercial videography, long-range surveillance along boarder regions, and environmental monitoring of remote locations.

**COST/BENEFIT ANALYSIS:** This technique will provide a cost-effective means of improving the ability to detect and identify targets far beyond current adversarial observation distances. Commercial applications will receive equivalent benefits. Since the proposed device can be completely assembled with commercial off-the-shelf integrated circuits, a cost-per-unit of less than a thousand dollars is achievable.

**OPERATING AND SUPPORT COST REDUCTION:** Technologies which result in efficient power sources will have a very positive effect on Operating and Support (O&S) costs.

**KEYWORDS:** Image processing, video processing, image enhancement, FLIR, target acquisition.

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1. D. Sadot, G. Lorman, R. Lapardon, N. Kopeika, "High-resolution restoration of images distorted by the atmosphere, based on an predicted atmospheric MTF", *Infrared Phys. Technology*, vol 36, pp. 565-576 (1995).
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#### U.S Army Research Office (ARO)

A99-125      TITLE: Hybrid Power Systems in the 10-50 Watt Power Range

TECHNOLOGY AREAS: Materials/Processes

**OBJECTIVE:** Develop the required system and control strategy for a hybrid power system which could provide a dismounted soldier with up to 50 W for 30 minutes, peak pulses on the order of several hundred watts, and a total energy budget of 1000 Whr in a package weighing less than 3 kg. Sustained (duration of the fuel supply) power levels of 15 W are desired.

**DESCRIPTION:** The Army, and particularly the Dismounted Soldier, has need for high energy, lightweight power sources. Battery technology is relatively mature, so dramatic improvements in energy density are highly unlikely. However, batteries have many desirable characteristics such as low signature, air-independent operation, instant startup, etc. Fueled systems consisting of very lightweight energy converters have energy densities limited by the energy density of the fuel. However, the systems typically require a source of air, may be difficult to start at low temperatures, and often have signature problems. The ideal system for supplying the electrical power required by the modern soldier appears to be a hybrid system consisting of a high density fuel supply, a lightweight energy converter, a battery charger, a high rate battery and perhaps a supercapacitor to handle pulse loads. A control system would sense when the battery is in need of charging, and turn on the primary energy converter to recharge the battery. Small fuel cells are among the most advanced new technologies which might provide the desired lightweight energy converter. Since the ideal fuel supply for small hydrogen/air fuel cells has not yet been developed, this solicitation will consider proposals for 'partial' hybrid systems using hydrogen/air fuel cells but not including the hydrogen supply. Proposals for complete systems will be given preference. Proposals containing energy conversion technologies other



than fuel cells will be considered. The system to be developed will be in close contact with soldiers; proposals which do not show rational consideration of the safety factors involved will be declined.

PHASE I: Identify and demonstrate a system which could lead to a hybrid power source that would satisfy the power/energy profile given in the objective statement. System models may be considered for the demonstration, but hardware systems will be given preference. The target volume for these power sources is 2000 cc. Safety, ruggedness, and performance (eg, operating temperature range) issues will be identified.

PHASE II: Reduce the Phase I 'benchtop' demonstration to practice in a fashion suitable for field testing. All safety issues will be addressed, and ruggedness and performance issues will be addressed where practical in a prototype, and quantified if they cannot be fully addressed. One complete system with six fuel cannisters will be delivered to the Army for test/demonstration. Prospective commercial users will be contacted.

PHASE III DUAL USE COMMERCIALIZATION: Developments in hybrid power sources will have immediate impact on a wide range of commercial power sources from computer power to emergency medical power supplies to recreational power uses.

OPERATING AND SUPPORT COST REDUCTION: Technologies which result in efficient power sources will have a very positive effect on Operating and Support (O&S) costs.

REFERENCES: ARO Workshop on Hybrid Power Systems, March 1998.

KEYWORDS: hybrid power, supercapacitor, fuel cells, control systems, soldier power

A99-126                      TITLE: Enhancements to Hand-held Electromagnetic Induction Metal Detectors for Unexploded Ordnance and Landmine Detection

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: To investigate and demonstrate affordable enhancements for handheld active Electromagnetic Induction (EMI) Unexploded Ordnance (UXO) or landmine detectors.

DESCRIPTION: Handheld mine detectors based on the principle of electromagnetic induction are effective in detecting metal mines and pieces of metal used in the firing mechanisms of non-metallic mines, however these detectors can have a very high false alarm rate due to an inability to discriminate targets, particularly the types and shapes of small metal firing mechanism parts, and they are not effective at localizing small metallic targets within their electromagnetic footprint. Techniques to improve discrimination, such as utilizing time or frequency response signal information or spatial signal distribution and statistical signal processing, have been reported in research articles. An effective technique for common mode rejection is the use of mechanically balanced bucking coils. Novel techniques such as electronically adaptive bucking coils, gradiometric measurements, or phase locked loops may provide cost or stability (mechanical and thermal) advantages. Techniques to improve localization using balanced coils have been effective, but reliable systems have been expensive due to fabrication costs. Innovative circuit techniques, using advanced methods such as MEMS adaptive circuitry or high temperature superconducting components, and advanced signal processing to take advantage of all signature information, have the potential for enhancements in detector performance at reasonable costs. New techniques for detecting the induced magnetic field in targets may provide better sensitivity and larger signal to noise ratios, which may enable the use of more sophisticated signal processing techniques. Automatic navigational and small computational components may allow the conversion of data from the imprecise sweeps of the handheld detector into accurate local spatial signal maps. Novel, innovative ideas are encouraged, they should not be limited to the previous examples. The baseline for comparison of enhanced performance is the AN/PSS-12 handheld detector, currently standard issue for US Army troops in the field.

PHASE I: Demonstrate feasibility of concepts as separate laboratory experiments or simulations. Demonstrate enhanced performance via analysis and experimental data (it is recognized that some performance parameters may require reasonable estimation from physical principles where measured data is unavailable). Perform preliminary cost analysis to demonstrate affordability of overall system concept.

PHASE II: Develop and demonstrate a prototype against metallic and low metal content antitank and antipersonnel landmines under realistic field conditions. Perform detailed cost analysis to demonstrate affordability of detector system.

PHASE III DUAL USE APPLICATIONS: Field trials at a specified Army location. EMI metal detectors are the primary detector for landmines for military countermining and civilian humanitarian demining operations. Affordable detectors with enhanced performance would have a large potential commercial market.

OPERATING AND SUPPORT COSTS REDUCTION: This capability could speed demilitarization of former ordnance impact zones on land to be returned to private use and shorten the time and risks involved in humanitarian demining operations.

REFERENCES: Detection and Remediation Technologies for Mines and Minelike Targets III, A.C. Dubey, J.F. Harvey, and J.T. Broach, Editors, Proceedings of SPIE Vol. 3392.

KEYWORDS: landmine detection, electromagnetic induction, magnetic induction, metal detector

A99-127 TITLE: Ammonia-based Hydrogen Sources for Small Fuel Cells

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop the required chemistry, catalysts, storage cannisters, and reactors to convert ammonia to hydrogen fuel for small (<500 W) hydrogen/air fuel cells (H/AFC). Sizes of particular interest are 10-50 W, 150 W and 500 W. Ammonia storage units should contain the equivalent of 500 to 1000 Whr.

DESCRIPTION: The Army, and particularly the Dismounted Soldier, has need for high energy, lightweight power sources. H/AFCs have been developed to the point where these energy converters can meaningfully augment the soldier's batteries, either as part of a hybrid system or as lightweight battery chargers. A primary obstacle to widespread use of small H/AFCs is lack of a convenient, inexpensive, safe source of hydrogen. Ammonia has high hydrogen content and is stable under most conditions, but can be decomposed to hydrogen and nitrogen. It can be stored as a liquid under modest pressure, and is a commodity chemical used worldwide. In addition to direct cracking to H<sub>2</sub> and N<sub>2</sub>, ammonia can be reacted with many compounds to generate hydrogen. Ammonia seriously degrades the performance of most H/AFCs, therefore, an ammonia-based hydrogen source must ensure an ammonia-free fuel stream.

PHASE I: Identify and demonstrate a process/system which could lead to a hydrogen source that would produce 1 Whr/g in the size range of 500 to 1000 g. The target volume for these sources is 500 - 1000 cc. Use a value of 1 g hydrogen = 17 Whr for estimating system performance. Safety, ruggedness, and performance (eg, operating temperature range) issues will be identified.

PHASE II: Reduce the Phase I 'benchtop' demonstration to practice in a fashion suitable for field testing. All safety issues will be addressed, and ruggedness and performance issues will be addressed where practical in a prototype, and quantified if they cannot be fully addressed. One complete system with six fuel cannisters will be delivered to the Army for test/demonstration. Prospective commercial users will be contacted.

PHASE III DUAL USE COMMERCIALIZATION: Developments in improved hydrogen sources will have immediate impact on utilization of small fuel cells as convenient, quiet, long-lasting power sources with low life cycle costs.

OPERATING AND SUPPORT COST REDUCTION: Technologies which result in efficient power sources will have a very positive effect on Operating and Support (O&S) costs.

KEY WORDS: Ammonia, hydrogen, cracking, fuel cell, fuel processing, microreactors

#### **U.S Army Aviation Research, Development, and Engineering Center (AVRDEC)**

A99-128 TITLE: Dual-alloy Technology for Turboshift Engines

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: Develop affordable, dual alloy bonding technology applicable to future gas turbine engine components to extend their operating temperature range.

DESCRIPTION: A significant opportunity exists in the application of advanced materials to many components of industry/Government gas turbine engines. The use of advanced materials will enable significant increases in power-to-weight ratios and reductions in specific fuel consumption. The advanced technology trend for future engines towards higher temperatures, and fewer stages, requires advancements in materials, processes and design concepts. Dual alloy components permit the best materials at the critical locations. Considerable design flexibility can be provided with the dual alloy concept. Bonding technology development is required for such a dual alloy component to be successful in an engine environment. Mechanical needs for the advanced, high performance impellers have identified the need for alloys to have strength and

temperature capabilities superior to the titanium alloy's used in today's engines. To minimize compressor weight while making high tip speeds and stage pressure ratios possible, new alloys and processes have been developed. Advanced titanium alloys, enhanced in strength by unique processing to achieve optimal microstructure, have been developed to extend the useful temperature range for the compressor. Thus, utilizing the dual alloy concept the impeller can be made using gamma titanium aluminide where creep resistance is needed and super alpha 2 or orthorhombic aluminide where high strength is needed. Mechanical limits on turbine components often limit cycle temperatures and blade loadings, and set cooling air requirements. Turbine disks are limited primarily by dovetail creep, bore LCF and overspeed capability. Disk envelope and weight can also be a limiting factor. Dual alloy turbine disks could use high creep strength alloys for the rim and high LCF strength materials for the bore. This technique would extend the useful temperature range over conventional superalloy disk materials.

PHASE I: Working with a gas turbine engine manufacturer identify bonding concepts for a dual alloy system applicable to a turboshaft engine component. Define both component and joint operational requirements. Evaluate the most promising bonding method in terms of strength and stability of the bond interface.

PHASE II: In conjunction with a gas turbine engine manufacturer and utilizing results of Phase I, apply the joining technology to a full scale turbine engine disk or impeller. Establish the physical, thermal, and structural properties of the dual alloy component. Verify the dual alloy concept through gas turbine rig and/or engine testing.

PHASE III: Focus on the commercialization of the bonding technology demonstrated in Phase II.

DUAL USE APPLICATIONS: The resulting technology will facilitate achievement of engine components having reduced weight, higher temperature capability, and/or increased durability. This technology will prove very beneficial to both the military and commercial sectors, being applicable to a wide variety of applications such as tank, automobile and aircraft primary power, heat exchangers, auxiliary power units, etc. The resulting product has a large potential market with enormous cost savings potential.

OPERATING AND SUPPORT COST REDUCTION: Technologies which result in increased power-to-weight and reduced specific fuel consumption while maintaining or increasing durability have a positive impact on Operating and Support (O&S) costs for future helicopters.

KEYWORDS: Gas Turbine Engine, Dual alloy disks, Dual alloy impeller, High Temperature Materials High strength materials

A99-129

TITLE: Aircraft Engine and Transmission Wear Monitoring Sensor

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: The objective of this effort is to develop and demonstrate an on-board sensor capable of detecting wear materials, contaminants, and lubrication properties of oil used in aircraft engines and transmissions. The sensor will be used in conjunction with on-board, vibration monitoring systems to trend wear in rotating components used in engines and transmissions. The trending data will be used by aircraft Health and Usage Monitoring Systems (HUMS) to project maintenance requirements and provide early detection of impending failures.

DESCRIPTION: The health of transmissions is currently evaluated by periodic vibration test flights and oil samples sent to a laboratory for analysis. Based on the results of the vibration test flight and oil analysis, the maintenance officer assesses the health of transmissions. HUMS is under development to monitor the health and usage of engines and transmissions in military helicopters. The HUMS resides on the aircraft and collects vibration data for analysis by the HUMS ground station. On-board sensors to evaluate wear materials, contaminants, and lubrication properties of the oil will increase the reliability of HUMS trending, as well as, early detection of impending failures that can be catastrophic. Safety studies indicate that as much as 25 percent of all helicopter losses could be avoided by early detection of impending failures.

PHASE I: The objective of Phase I is to demonstrate, in a controlled environment, the accuracy and reliability of a sensor capable of detecting wear materials, contaminants, and oil properties. The sensor must prove to be accurate, reliable, lightweight, and adaptable for aircraft applications.

PHASE II: The Phase II objectives are to demonstrate the effectiveness of the sensor in seeded fault tests using a gearbox on a test stand and adapt the sensor for aircraft use.

PHASE III: The Phase III objectives are to qualify the sensor for flight; test the sensor on a test aircraft; and integrate the sensor data into a HUMS.

DUAL USE APPLICATIONS: The resulting technology will be applicable to both military and commercial aircraft, automotive, trucking, and marine markets, as well as, any other market using engines and transmissions.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Various HUMS cost benefit analyses show a reduction in O&S costs and a return on investment at 1-3 years.<sup>1,2</sup> An on-board wear monitoring sensor is an enabling technology for maximizing the HUMS potential.

KEYWORDS: Wear Materials, lubrication, HUMS, Engines, Transmissions

REFERENCES:

- (1) "Cost/Benefits Analysis for Integrated Mechanical Diagnostics," prepared by the Charles Stark Draper Laboratory for Naval Air Systems Command, April 1997.
- (2) "HUMS/ADR Benefit Assessment," by Stewart Hughes Limited, October 1994.

A99-130                      TITLE: Lightweight Double Helical Gears for Aerospace Applications

TECHNOLOGY AREAS: Air Platforms

OBJECTIVE: The objective of this effort is to develop a manufacturing process that can significantly reduce or eliminate the gap currently required to produce hardened and ground, aerospace quality double helical gears and thus reduce their weight.

DESCRIPTION: Double Helical (DH) gears are desirable due to their low noise characteristics, damage tolerance due to high contact ratio, and zero net thrust loads. DH gears are starting to find their way into more and more performance critical aerospace applications, especially ones where low noise is a prime consideration. The Army's Comanche Helicopter utilizes a large DH gear in the final stage of its main rotor transmission. It is anticipated that future designs will follow this trend. Aerospace quality power gears are typically case hardened for maximum load capacity and durability. Grinding of the teeth is required to obtain the final finished dimensions. A gap between the left and right hand sides of the DH gear is currently required in order to allow the grinding wheel access to the full tooth surfaces without interference with the adjacent teeth. The presence of this gap increases the weight of this type of gear. The use of shaper cutters and small grinding wheels has reduced this gap over the years. Currently, helicopter gears with a whole tooth depth of 0.30 inches require a gap between the left and right hand of not less than 0.7 inches. A manufacturing technique that can greatly reduce or eliminate this gap is desired.

PHASE I: The effort in Phase I will focus on the development and demonstration of the key technical challenge(s) associated with the proposed approach. Small scale trials of the manufacturing technique shall be conducted to prove the feasibility of the process. The trials shall utilize representative materials and tooth geometries and be evaluated for their capability to produce the desired tooth profile, surface finish and minimum gap size.

PHASE II: The Phase II effort shall focus on the scale up of the process to allow large size DH gears to be fabricated. The Phase II effort shall conclude with the demonstration of the capability to fabricate a hardened and ground DH gear with dimensions similar to those of the Army's Comanche helicopter with the gap significantly reduced or eliminated.

PHASE III DUAL USE APPLICATIONS: This technology has the potential to be applied in all types of aerospace applications including commercial rotorcraft and fixed wing passenger aircraft. It would also be attractive to the automotive industry due to the low noise characteristics and reduced size.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: This effort will impact the operating and support costs of the Army's rotorcraft by reducing empty weight and thus reducing the amount of fuel required to perform a given mission.

REFERENCES: Sikorsky Aircraft Advanced rotorcraft Transmission (ART) Program - Final Report, March 1993, NASA Contractor Report 191079, Army Research Laboratory contractor Report ARL-CR-49

KEYWORDS: gears, grinding, double helical

A99-131                      TITLE: Battle Damage/Fault-tolerant Reconfigurable Open Systems Avionics Architecture

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: This research and development effort will demonstrate a reconfigurable open systems avionics architecture designed for an inherently high degree of battle damage and fault tolerance.

DESCRIPTION: Modern fielded rotorcraft avionics systems suffer very high acquisition, operating, and support costs. This is due not only to their levels of sophistication but also to the fact that most, if not all, consist of custom hardware built to military

specifications. Moreover, these avionics systems are difficult and expensive to upgrade due to the wide proliferation of closed proprietary interfaces and to the rapid obsolescence of critical computer architectural elements. As a result, open systems architectures are being investigated for application to many weapon systems (ground, sea, and airborne). Open systems will enable the military to use commercial and industrial grade components thereby capitalizing on the "economy of scale" and reducing acquisition, operating, and support costs. However, commercial and industrial grade equipment is frequently not suitable for demanding military operational environments and reliability requirements. Two key attributes for Army aviation weapons systems are that they must be battle damage and fault tolerant. In general, redundant systems are employed for these purposes; however, this solution comes at the expense of adding black boxes. Computer processor functional reconfiguration techniques may make it possible to reduce component count and retain expected levels of fault tolerance within the constraints of an open systems design. This work will enhance the Army's understanding of battle damage and fault tolerance issues associated with the use of commercial off-the-shelf equipment and enable fielding in a more expeditious manner.

PHASE I: The contractor will analyze Army aviation battle damage and fault tolerance requirements and develop an overall system design to meet these requirements for a highly integrated open systems avionics architecture. The design will be comprehensive in nature considering all aspects of the architecture. The contractor will develop guidance, specifications, and design strategies that contribute to a battle damage and fault tolerant design. These designs and specifications will be consistent with the Joint Technical Architecture - Army (JTA-A) and with open systems specifications, standards, products, and processes.

PHASE II: The contractor will fabricate and integrate a prototype battle damage/fault tolerant open systems avionics architecture and demonstrate it in a bench test environment. The avionics architecture will use market driven commercial-off-the-shelf equipment and components to the maximum possible extent. The contractor will host mission systems software on the selected processing platform and demonstrate reliable operation and reconfigureability under simulated fault inducing and battle damage conditions. This demonstration will be conducted within a simulation based avionics integration environment.

PHASE III DUAL USE APPLICATIONS: This system could be tailored for use by both commercial and military helicopters and fixed wing aircraft. It might also be applied to various ground vehicles. The results of this research will be used to support Army Science and Technology work in the area of open systems avionics architectures and integration. If successful it may also be applied to the RAH-66 Comanche and AH-64D Longbow helicopters and to civilian rotorcraft.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Open systems computer architectures will enable the Army to use commercial and/or industrial grade equipment for the integration of avionics systems on manned and unmanned rotorcraft. This directly reduces acquisition costs, enables more affordable upgrades as new capabilities are developed, and increases the useful life of the weapons system.

KEYWORDS: Open Systems, Avionics Architectures, Battle Damage Tolerance, Fault Tolerance

A99-132 TITLE: Graphics Display Systems for Night Vision Goggles (NVG)

TECHNOLOGY AREAS: Human Systems

OBJECTIVE: The objective of this SBIR is to reduce the cost of installing graphic (symbology) display systems which are used on rotorcraft night vision goggles (NVGs). A number of manufacturers make NVG displays, graphics generators, and associated sensors. However, each type of helicopter has a different design for the installation of the sensors and the graphics generator. For this SBIR, a single, integrated package of sensors and associated graphics generator is developed which can be bolted onto a number of different types of rotorcraft airframes, with minimal modification to the airframes.

DESCRIPTION: Night vision goggles are used by military and civil rotorcraft operators to increase the usable operating hours of the aircraft. To increase safety while flying low level at night, graphic information (symbology) is added to the NVG display to provide critical flight information to the pilot. This information includes aircraft altitude above the ground, aircraft attitude, direction and magnitude of aircraft velocity in three dimensions, direction and magnitude of aircraft acceleration in three dimensions, and direction to navigation waypoints. Data accuracy, update rates and lags must be taken into account in order for the information to be usable by the pilot to control the aircraft for extended periods of time. Typical, current installations of graphic displays for NVGs include inertial sensors, radar/laser altimeter, heading reference sensor, global position system (GPS) receiver, graphics generator, NVG display, and possibly a head tracker. The components are typically distributed throughout the airframe, which increases the cost of installation. Additional cost usually occurs when installing into a new airframe, since the system design typically varies with the airframe. For this SBIR topic, an integrated, bolt-on, sensor and graphics generator package will be developed to make installation into any rotorcraft easier and less costly. The package will be designed to work with different off-the-shelf displays and head trackers. The graphics generator should detect sensor failures in flight, and blank out incorrect information. The package should also perform self-calibration checks of the sensors during the preflight or start-up. In order to accommodate different displays and recorders, the graphics generator should have

programmable video output to include composite video (RS-170) as well as RGB video (640 x 480, 1280x1024). The graphics generated should be user programmable using the C language, with OpenGL libraries. Proposing companies have complete flexibility in formulating the approach to this topic. Innovative approaches should be developed. SBIR proposals that meet the general goals of the solicitation topic, but do not meet specific goals or approaches will be considered.

PHASE I: Proposals should include a concept level design for the packaging and installation of the system described in this topic as well as a list of the expected types of sensors. Phase I proposals should also include human-factors based targets for data accuracy, update rates and lags. For the Phase I effort, a preliminary design of the NVG graphics generator system detailed in this topic should be completed up to the point that cost and performance can be estimated to within a target of plus or minus 20%.

PHASE II: Design, fabricate, test, and deliver to the US government one complete NVG graphics display package. This package will include the sensor and graphics generator system described in the topic, an AN/AVS-6 night vision goggle (or superior replacement), a graphics display for the night vision goggle, and a head tracker that can be operated inside the cabin of a helicopter. Demonstrate during a helicopter flight that all system components work together to provide critical flight information to the pilot. The list of critical flight information is detailed in this topic. For the demonstration, the contractor should expect to rent time on a civilian helicopter, since the Government cannot guarantee that a helicopter will be available for this test. Deliver two sets of documentation including specification sheets, quality test reports, electrical schematics, software documentation, operator's manuals and maintenance manuals.

PHASE III DUAL-USE APPLICATIONS: This device has the military benefit of improving NVG helicopter operations. In addition, this device is very useful to civilian medical evacuation helicopters, law enforcement helicopters, and offshore transport helicopters.

OPERATING AND SUPPORT COST REDUCTION (OSCR): Reducing helicopter accidents while operating at night is the goal of this SBIR topic. Besides the more important goal of saving lives, there is also the potential for a significant cost savings associated with reducing helicopter accidents during routine night operations.

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- 3.<http://www.monmouth.army.mil/peoiew/pmnvrsta1/anvis.htm>
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5. Head-Mounted Displays II, SPIE Proceedings, Vol. 3058, 1997 (1) Aeronautical Design Standard: Handling Qualities Requirements for Military Rotorcraft, ADS-33D-PRF, May 1996 (2) S. W. Baillie and R. H. Hoh, "The Effect of Reduced Useable Cue Environments on Helicopter Handling Qualities," Canadian Aeronautics and Space Journal: 34, 1988, 144-150 (3) R. H. Hoh, Investigation of Outside Visual Cues Required for Hover, AIM Paper 85-1808, August 1985 (4) D. C. Hart, ADS-33C Flight Test Maneuvers Validation In A Degraded Visual Environment," presented at 50th Annual AHS Forum, May 1994 (5) A. G. Ledebuhr et al, "WFOV Star Tracker Camera," Sensors and Sensor Systems for Guidance and Navigation, Proceedings SPIE, 1478, April 1991, pp.2-12 (6) M. R. Franklin, "Application of an Autonomous Landing Guidance System for Civil and Military Aircraft:" Synthetic Vision for Vehicle Guidance and Control. Proceedings SPIE, 2463, April 1995, pp. 146-153 (7) P. K. A. Menon, G. B. Chatterji, and B. Sridhar, "A Fast Algorithm for Image-Based Ranging," Sensors and Sensor Systems for Guidance and Navigation. Proceedings SPIE, 1478, April 1991, pp.190-200 (8) R. E. Zelenka, P. N. Smith, A. A. Coppenbarger, C. E. Njaka, and B. Sridhar, "Results from the NASA Automated Nap-of-the-Earth Program, "Journal of the American Helicopter Society: 47,1997,107-115 (9) R. L. Newman, Scheme for Automatic Declutter for Helmet-Mounted Displays and Head-Up Displays, Crew Systems TM-96-03 submitted to Aeroflightdynamics Directorate, Moffett Field, February 1996 (10) M. J. Wells and M. Haas, "The Human Factors of Helmet-Mounted Displays and Sights," in Electro-Optical Displays, M. A. Karim (ed.), New York: Dekker, 1992, pp.743-785 (11) D. F. Kocian and H. L. Task, "Visually Coupled Systems Hardware and the Human Interface," in Virtual Environments and Advanced Interface Design, W. Barfield and T. A. Furness (eds.), New York: Oxford University Press, 1995, pp.175-25. (12) E. T. Davis, "Visual Requirements in HMDs: What We Can See and What Do We Need to See," in Head-Mounted Displays: Designing for the User, J. E. Melzer and K. Moffill (eds.), New York: McGraw-Hill, 1997, pp.207-251 (13) C. E. Rash, B. T. Mozo, BC J. McEntire, J. L. Haley, J. R. Licina, and L. W. Richardson, Assessment Methodology for Integrated Helmet and Display Systems in Rotary-wing Aircraft , USAARL 96-16 June 1996 (14) R. L. Newman, Head-Mounted Display Design Guide, Army Report TR-(pending), November 1997; Crew Systems TR-97-11 (15) R. L. Newman, Helmet-Mounted Display flight Symbology Requirements for Military Rotorcraft, Crew Systems TR-98-1 2, May 1998

KEYWORDS: night vision goggles, graphics display

#### TECHNOLOGY AREAS: Air Platforms, Materials/Processes

**OBJECTIVE:** To develop a low cost, fuel system computer to monitor fuel flow, quantity, endurance and system health. This project addresses goals of the Air Vehicle Technology Area Plan to achieve a 25% reduction in crew workload, a doubling of decision making accuracy, and a quadrupling of situation awareness. The project will enhance pilot situation awareness and reduce workload by automating routine but potentially error prone fuel management tasks. It will provide the crew up-to-date, accurate information for aeronautical decision making. It will also provide timely alerts.

**DESCRIPTION:** Modern aircraft carry advanced fuel systems to improve engine performance and fuel efficiency. Yet the information provided to the crew by the fuel system has changed little from the earliest, mechanical gauges. The hardware and software technology exists for precise monitoring of fuel usage and quantity on board. This technology can provide the crew with timely and accurate fuel status information both under normal operating conditions and under conditions when manual accuracy might be poor. A major obstacle to placing this technology in aircraft is the high cost of developing and certifying a flight worthy device. This project will develop a low cost flight worthy device that will monitor fuel status, work with navigational systems to compute endurance, and alert the crew in case of a hazardous fuel status.

**PHASE I:** Identify a low cost, technical approach and design for the project. The design will include sensors for fuel flow and pressure as well as software and display format/presentation concepts. A proof of concept demonstration at the end of Phase I will include operating a brass board monitoring system and simulating the crew interface.

**PHASE II:** Develop a low cost fuel monitoring system and install it on an Army aircraft at Ames Research Center, Moffett Field, CA. The contractor will flight test monitoring hardware, software, and display formats/presentations. The demonstration system will be evaluated for usability and effectiveness as well as for cost and suitability for existing rotorcraft.

**PHASE III DUAL USE APPLICATIONS:** This system can have a great impact on civilian safety. Recent safety studies by NASA have analyzed civil rotary wing aircraft accidents listed in the NTSB data base. These studies have shown fuel starvation to be one of the most common factors in civil accidents. In many cases fuel starvation is the result of a sequence of crew errors that lead to an underestimate of endurance. Timely, accurate fuel status information and appropriate alerts could greatly reduce the number of fuel starvation accidents. Since a major stumbling block for the widespread use of fuel management computing systems is the high cost, the development of a low cost system should do very well in the civil market, both for rotary wing and fixed wing aircraft.

**OPERATING AND SUPPORT COST REDUCTION:** Operating cost reductions will be obtained mainly from enhanced combat performance due to better fuel management. Combat performance will be enhanced through the pilot's improved situation awareness of fuel status close to the limit of the endurance envelope. The system will also provide a great benefit in actual combat, where maximum endurance can be critical. The system can both enhance combat effectiveness and reduce losses. Although the system's potential to impact safety of military training is smaller, because training missions are less likely to push the endurance envelope, it could allow more realistic training by simulating performance near the edge of the endurance envelop.

#### REFERENCES:

1. "ASRS Rotorcraft Incident Study, Data Summary," January, 1999.
2. Hart, S. G., "Results of Safety Analysis Workshop," invited paper at The AHS Forum, May 1998, Washington.
3. Hart, S. G., "Analysis of Civil Helicopter Accidents," HeliExpo '98, February, 1998.
4. Schwirzke, M. F. J., Workshop on Near Term Gains in Rotorcraft Safety Strategies for Investment, NASA Ames Research Center, July 1998, Mountain View, CA.

**KEYWORDS:** fuel, fuel monitoring, crew alerting

#### U.S. Army Communications and Electronics Command (CECOM)

A99-134                      TITLE: Low-cost Helicopter Collision Warning System

#### TECHNOLOGY AREAS: Air Platforms

**OBJECTIVE:** To provide helicopter pilots early warning of developing collision (contact) situations.

**DESCRIPTION:** Damage, destruction and fatalities result when helicopters contact aerial (other helos and wires) and ground objects (towers, buildings, standpipes, trees, hills, cliffs, guy-wires, etc.) in both extra-ordinary and routine situations. A

relatively small and inexpensive stand-alone/retro-fittable system is needed to warn pilots in a timely yet unobtrusive manner of developing dangerous contact situations. This means sensing, tracking and evaluating objects in roughly the lower hemisphere out to around 100 meters (600 m or more in the forward direction). Only combined approach speeds less than 100 m/sec need be considered. The system must not significantly impact or endanger current helicopter operations. Proposals should also provide a preliminary estimate of power, size, weight, and cost.

PHASE I: A tradeoff study will be conducted to determine a limited set of radar sensors which will satisfy the goals. These will then be used to define an operational system configuration for the targeted UH-1 Huey test helo. (The design must be extensible to other helo categories with only minor modifications.) A detailed design will be prepared, and the bench functionality of one key sensor will be demonstrated.

PHASE II: The detailed design and sensor set determined in phase I will be used to construct and demonstrate one full mounted system, including a non-interference test. (This may require multiple units on two helos, depending on design.) The tests will be run using Army helos at Lakehurst Naval Air Station in New Jersey.

PHASE III DUAL USE APPLICATIONS: The proposed configuration will have an almost identical use in the commercial helo transport fleet, which encounters the same situations as the military fleet. Depending on the design, it might also be applicable to some small fixed wing aircraft.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Even minor contacts can result in structural damage to helicopter blades and fuselage. This occurs quite often and involves considerable cost to satisfy air safety regulations. Saving lives in peacetime training is a high priority.

KEYWORDS: Helicopters, collision avoidance, sensors



## TECHNOLOGY AREAS: Information Systems Technology

**OBJECTIVE:** The proposed effort will develop and model the distribution of RF communications equipment associated with specified deployed battlefield entities and organizational units in a simulated environment. Further, the deployed Semi-Automated Forces (SAFOR) will produce simulated communications traffic for a variety of tactical battlefield situations. The resulting communications simulation and modeling products will be integrated into an existing, off-the-shelf, tactical battlefield simulation system with Distributed Interactive Simulation (DIS) and High Level Architecture (HLA) compliant protocols.

**DESCRIPTION:** In current Distributed Interactive Simulation (DIS) environments, there exists a limited capability to model RF communications equipment accurately. Further, the modeled communications devices must correlate with battlefield entities or units, for DIS/HLA exercises. This type of representation on the electronic battlefield is required in the Intelligence and Electronic Warfare community to describe tactical situations accurately. There exists in the IEW community, systems that exploit information gained through the interception of communication traffic such as GUARDRAIL and Rivet Joint. Therefore, an accurate portrayal of potential target system is necessary in determining the performance of these collection systems under a variety of battlefield scenarios. The ability of such systems to perform missions in a DIS/HLA exercise environment is considered a highly desirable goal since these systems are expensive high value assets to deploy.

**PHASE I:** An initial investigation in determining the organizational makeup of forces that can be represented as Semi-Automated Forces (SAFOR), distributed on the battlefield and the communications devices deployed with these forces will be performed. From this initial analysis, a sub-set that provides a spectrum of RF Communications models is developed. The development of software models that accurately describes the parameters of the selected systems is then constructed. Typical parameters would include power, frequency, bandwidth, beam characteristics and other salient characteristics. After model development, next is tethering or attaching the communications model to an entity that has a representation or known model in the DIS/HLA environment. As the model is exercised through various scenarios, data will be collected on the performance of a communication collection system. The performance of multiple scenarios will generate a range of data sets that provide system sensitivity analysis.

**PHASE II:** This phase of the effort will address the development of an automated deployment system for larger forces a Distributed Simulation of tactical battlefield operation. On a simulated battlefield, the rapid and efficient deployment of numerous forces using a wide range of equipment associated with each entity is required. It is proposed that an Expert Systems and/or several AI techniques can be utilized in defining these deployment patterns, strategies and equipment distributions on the synthetic battlefield. Target areas for these technologies are as follows: - Use of templates or expert systems software in defining deployments. - Tactical situation deployment of forces based on preset rules. - Varying deployment patterns based on tactical situations or opponent type. In determining the organizational makeup of the Semi-Automated Forces (SAFOR) distributed on the battlefield, several factors comprising the characteristics of specific entities or units on the battlefield with associated communication capabilities require investigation.

**PHASE III DUAL USE APPLICATIONS:** The developed models and simulation techniques possess practical application for other than DoD agencies. An example of this extends to modeling communication devices on transportation vehicles such as trucks and trains. Utilizing Global Positioning System (GPS) along with a database of communication relays, mobile systems can determine potential link and loss of link using these tools. When the communications link is lost, the tool would direct the operator toward locations along its general direction or route where reacquiring the link is possible. Further, this tool would alert a operators as to when a unit would lose communication during a delivery or voyage.

**OPERATING AND SUPPORT COST (OSCR) REDUCTION:** Utilization of these modeling and simulation techniques will provide enhanced operator training on sensor and INTEL collection systems such as Guardrail, Joint STARS and ASAS at reduced cost to train. The ability to train operators without the deployment of high value assets is highly desirable and cost effective.

**KEYWORDS:** Distributed Interactive Simulation (DIS), High Level Architecture (HLA), Guardrail, Joint STARS, Communication Modeling

## TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

**OBJECTIVE:** Demonstrate significantly enhanced capability to provide a near-real time map of RF emitter locations in the tactical commander's battlespace. Improvements are sought in both system performance and system SWAP (size, weight, and power).

**DESCRIPTION:** The tactical commander requires a near-real time map of RF emitter locations, including emitter type identification, in the battlespace. This map contributes directly to the all-source intelligence picture of the disposition of both friendly and enemy forces, and is critical to force protection/situation awareness, situation development, and targeting. Currently, the Army relies on a mix of ground, air, and national assets to provide this picture. However, the performance of each of these assets is limited in some particular aspect. Limitations include line-of-sight, field of view, sensitivity, dynamic range, geolocation accuracy, size, weight, power, etc. In particular, operational trade-offs must be made between system performance and system range to target (i.e., large, sophisticated systems operating at stand-off ranges versus attritable systems operating at stand-in ranges). Opportunities for performance improvements exist in several areas. Vehicular applications require compact, mechanically robust, high-gain or reconfigurable antennas capable of acquiring data for on-the-move direction finding. Operation in dense environments requires enhanced spatial signal separation techniques. Operation against modern, low-power commercial emitters requires high-dynamic range and low-noise broadband digital receivers. Tracking of specific emitters within a communications net places particular emphasis on techniques and hardware for reliable, high-confidence electronic fingerprinting. Opportunities for SWAP improvements include the application of low-power electronics, advanced packaging techniques, and advanced hardware/software configurations.

**PHASE I:** Identify candidate improvements, develop initial designs with analysis of return-on-investment in the area of improvement, and demonstrate technical feasibility of the recommended approach.

**PHASE II:** Develop and demonstrate a prototype version of the improvement. Hardware should provide maximum possible compatibility with the Joint Airborne SIGINT Architecture (JASA) and other relevant standards. Hardware will be delivered for test and evaluation in concert with existing SIGINT systems at CECOM.

**PHASE III DUAL USE APPLICATIONS:** Hardware developed under this topic will have potential application to RF site-survey activities for the planning and construction of cellular communications networks.

**OPERATING AND SUPPORT COST (OSCR) REDUCTION:** Improvements in SWAP will have collateral impact on logistics and support costs associated with transportation, fuel supply and storage, etc.

**REFERENCES:** Further details on Army requirements for near-real time RF emitter mapping may be found at the TRADOC System Manager - Ground Based Common Sensor (TSM-GBCS) website at <http://huachuca-dcd.army.mil/tsmgbc/s/m.htm>. Interested parties may request the Operational Requirements Document (ORD) for the Prophet System from TSM-GBCS by following the instructions as noted on the website. The JASA Standards Handbook is available via the JASA Standards Working Group (JSWG) website at <http://www.jswg.org>.

**KEYWORDS:** situation awareness, signals intelligence

A99-137                      **TITLE:** Low-cost Modular Intelligence System

**TECHNOLOGY AREAS:** Sensors, Electronics, and Battlespace Environment

**OBJECTIVE:** Design and develop a low cost, scalable, intelligence analysis system.

**DESCRIPTION:** Current Army intelligence analysis systems require bulky, expensive hardware and are not designed to support multiple intelligence disciplines. Additionally, they require the purchase of expensive commercial off-the-shelf (COTS) software licenses, further increasing the cost of ownership and making them too expensive to be widely deployed. The objective of this effort is to develop an intelligence analysis system that has: 1) reduced hardware cost; 2) reduced cost of ownership; 3) reduced size and weight; 4) Defense Information Infrastructure/Common Operating Environment (DII/COE) compliance; and 5) functional modularity. Functional modularity will allow the user to select each individual intelligence discipline [e.g., Communications Intelligence (COMINT), Electronics Intelligence (ELINT), Human Intelligence (HUMINT), etc.] and install only the functionality required to perform the current mission. The system must allow the user to configure the software to interface with existing intelligence sources and systems. Potential offerors shall ensure that product design accommodates segmented, multi-level security as required to interface with existing intelligence sources and systems.

**PHASE I:** The contractor shall design the hardware and software architecture of the system incorporating the concepts and requirements of the description above. The system shall be designed to be implemented on a Windows 95, Windows 98, or Windows NT platform. The software shall be designed for implementation in C++. Deliverables shall consist of a final report that addresses the issues of cost, size and weight savings over current Army analysis systems, includes the

system design architecture, addresses dual-use prospects of the system, and a feasibility assessment of the system. Evaluation factors shall include compliance with the solicitation, innovative merit, relevant experience and dual-use.

PHASE II: The contractor shall implement the Phase I design of the system. The contractor shall test and demonstrate that the system implements and complies with the requirements of the description above. Deliverables shall consist of five complete systems, a test & demonstration plan, a final report of the test & demonstration results, and the C++ source code and makefiles used to compile the software. The C++ source code shall not invoke any executable user files, unless the C++ source code for such files is also delivered to the Government.

PHASE III DUAL USE APPLICATIONS: The resulting system will provide a low-cost intelligence analysis capability for law enforcement (FBI, DEA, CIA, Customs) operations and counter-drug operations. For example, this system may be used by these agencies to correlate and track electronic emissions from sources such as radio transmitters and cellular phones against other sensor data, such as ground vehicle movement data, in real time and on the move. Additionally, this system could be used by the FCC as a low cost, backup, tracking system for air traffic control systems by taking advantage of multi-sensor correlation of radar and communications information.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: This topic will support reduced up-front costs for hardware and software as well as reduced support costs for the system's lifecycle in terms of repair and software licensing.

REFERENCES: Product Manager, Intelligence Fusion, All Source Analysis System Homepage:  
<http://www.asaspmo.belvoir.army.mil/asas/asas.htm>

KEYWORDS: Intelligence analysis, surveillance, fusion, correlation

A99-138 TITLE: Physically Small, Very High-frequency/Ultra-high Frequency Conformal Antennas

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: The proposed effort will develop and construct a VHF/UHF antenna which is both lightweight and small and can be mounted on a tactical Unmanned Aerial Vehicle (UAV) such as Outrider.

DESCRIPTION: A need exists for an antenna that can be used on tactical UAVs. At VHF/UHF frequencies, current technology requires an antenna be either large, or have inadequate electrical performance. It is desired that the developed antenna will work from 20 MHz to 2GHz, with a directivity greater than 3dB, and a VSWR across band of better than 3.0:1. These goals should be met with the antenna mounted on a UAV and not only in a lab type environment. Two antennae that meet this requirement needs to be mounted on each UAV. Meeting the electrical goals fully is not required, though it is highly encouraged. The use of new architectures, such as fractal designs and or the use of new materials is encouraged. If full electrical performance can not be met from one antenna, a possible solution can be the combination of a number of antennae.

PHASE I: This initial phase should include extensive modeling of the desired antenna or antennae and if possible, the development of proof of concept models for verification. The antenna should be designed to mount on a small tactical UAV such as Outrider. Modeling should include the problems encountered from mounting the antennae on a UAV. Phase I should include a detailed plan for constructing the antenna or antennae in Phase II.

PHASE II: This phase will include design, fabrication and testing of the final antenna or antennae. Final testing should be done in an anechoic chamber and if possible also mounted on a structure similar to a small tactical UAV. Two each of every antenna should be constructed and delivered upon completion of this phase.

PHASE III DUAL USE APPLICATIONS: Possible dual use applications include the use of this technology in the commercial communications field. Successful completion of this project will allow antennae used in cellular base stations, short wave communications and other VHF/UHF applications to be smaller and/or have improved electrical performance, potentially decreasing the costs and increasing the utility of these systems.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Utilization of these antenna(e) on a UAV for reconnaissance purposes will allow a significant reduction in cost over what can be accomplished with present day technology, i.e. piloted aircraft.

REFERENCES: [http://roselott.gsfc.nasa.gov/html/valvidia/fractal\\_antenna/node1.html](http://roselott.gsfc.nasa.gov/html/valvidia/fractal_antenna/node1.html)  
<http://www.neci.nj.nec.com/pompages/vlasov/photonic.html>

KEYWORDS: antenna, UHF, VHF, conformal



A99-139

TITLE: Tactical Vehicle Inverter System

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop a new electrical inverter system which provides tactical vehicles with sufficient usable, onboard electric power to meet mission requirements.

DESCRIPTION: The Army has a need to process power from the 28 volt DC electrical system onboard tactical vehicles into usable 120/240 volt, 60 Hz, single phase AC power to support a variety of mission functions, i.e. Signal, Communications, Contact Maintenance, Mobile TOCs, etc. The Light and Medium families of tactical vehicles are available with DC systems up to 400 amperes (11.2 kilowatts). Armored vehicles have even higher DC system capabilities. The maximum capabilities of these systems are not always necessary to perform vehicle operations, and, therefore, this surplus power can be applied to a conversion unit to produce AC power. These units will be capable of producing 2.5 kilowatts (kW) of 120/240 volt AC power each. The units will be selectable between 120 volt AC Single Phase and 240 volt AC Single Phase via a switch, or by having separate output connectors for the respective voltages. The units will be physically secure to one another and electrically interface as to parallel the outputs to produce 120/240 volt AC Single Phase power in multiples of 2.5 kW (2.5 kW, 5 kW, 7.5 kW, ...etc.). The only vehicle interface required will be to plug into the NATO battery slave receptacle. This allows the power converter to be generic and adaptable to all tactical vehicles. These converters must operate in the critical ambient temperature conditions required for tactical equipment (-32 Degrees C to +52 Degrees C). The power produced by these units is required to meet Mil-Standard 1332B, Utility Class 2C, for power quality.

PHASE I: Explore the technologies and components available to determine the approach best suited to meet the Army's need for a generic vehicle power conversion system, employing the latest technologies in power electronics, and develop a design which meets these criteria.

PHASE II: From the design developed under the Phase I effort, fabricate and deliver four operational prototype vehicle power conversion systems. Multiple units are necessary to confirm the paralleling capabilities. The paralleling of the conversion units provide them with the unique capability of producing multiples of the individual unit power rating. This will allow adaptability to virtually any military or commercial application requiring 120/140 VAC power originating from the vehicle electrical system.

PHASE III: Providing dual voltage input capability to the power conversion unit, allowing either 12 or 24 VDC, will permit this technology to meet military and civilian commercial applications. This technology under Phase III would transition to production to provide power conversion systems which are adaptable to all military tactical vehicles and a large segment of commercial vehicles as well, i.e., Fire & Rescue, Forestry, Utility Power Maintenance, Disaster Relief, Commercial Trucking, Recreational Vehicles, etc.

OPERATING AND SUPPORT COST REDUCTION (OSCR): These inverter systems will provide the necessary electrical power to meet critical mission requirements while eliminating the need for many Diesel Engine Driven (DED) Generator Sets or Auxiliary Power Units (APUs). Using these inverters, when suitable, will not only reduce initial equipment costs over generator sets and APUs, but will also reduce, operational and maintenance costs, and transportability and logistics. Each inverter will weigh but a few kilograms and be less than .03 cubic meters in size. These units can be easily transported in their host vehicle without a significant increase in size or weight. The Generator Set or APU, which these inverters can replace, range in size from .5 to 11 cubic meters and weigh between 100 and 2,000 kilograms. Generator sets and APUs require routine maintenance, therefore, maintenance and repair parts and trained personnel must be available in the field to support them. These inverter systems will not only eliminate the initial cost of the Generator Set or APU, they will also reduce the logistics burden by, decreasing the volume and weight of deployed equipment, and reducing the necessary maintenance and repair parts and personnel which support this equipment.

KEYWORDS: Inverter, converter, 28VDC, 120/240VAC, Vehicle Interface

A99-140

TITLE: Lightweight Integrated Navigation and Communications Radio System

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: To design, build, and demonstrate an affordable, anti-jam, LPI integrated navigation and secure communications system that offers precision relative navigation and rendezvous capability to Army mobile platforms, including the soldier.

DESCRIPTION: In order to make future multi-function radios affordable on many Army platforms it is highly desirable to utilize the same frequency spectrum for both navigation and communication functions, thereby eliminating the requirement for

additional antennas and RF front-ends. Innovative concepts are required that facilitate realization of this objective by addressing problems of: susceptibility to enemy jamming threat, detection by the adversary, self interference, and interference to friendly users not equipped with the proposed system.

PHASE I: The purpose of Phase I is to conduct research and risk reduction through trade studies. The contractor will develop the system architecture and concept of operation.

PHASE II: The objective of Phase II is to demonstrate key technology areas through laboratory tests. Completely define their system specification and prepare a final report.

PHASE III DUAL USE APPLICATIONS: The proposed system will benefit manned and unmanned aircraft guidance, command and control, search and rescue, surveillance and reconnaissance, precision approach and landing systems to suit the needs of commercial users. Military applications include situation awareness and precision relative navigation between non line-of-sight mobile platform.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: This topic increases and improves the commander's situation awareness, and provides the capability to issue short commands, without resorting to high power transmitters which give away force location. This capability minimizes the need for more expensive antenna and RF components, thus reducing logistic support expenditure.

REFERENCES: Small Unit Operations Situation Awareness System, System Capabilities Document Version 2.0 March 10, 1998

KEYWORDS: communication, radio, navigation, low probability interception, RF

A99-141                      TITLE: Application of Distance Learning to Training Cost Reduction for Logisticians and Command Post XXI Staff

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: To develop, demonstrate, and transition innovative Distance Learning technologies for training cost reduction for logistics and command post staff.

DESCRIPTION: The need exists for major improvements in training and knowledge acquisition in the area of logistics and command post operations. As the battlefield becomes faster-paced and more complex, and as budgets decrease, the need for cost reduction/enhancements in training and knowledge acquisition is becoming increasingly critical. Distance Learning (also called Distributed Learning or Learning Technology) offers great potential for meeting these needs. While this topic is open to any new technologies addressing this field, offerors should consider focusing their proposals on one of the four emerging Learning Technology standards recently adopted by The Joint Technical Architecture-Army (JTA-Army) [1. Learner Model; 2. Learning Technology Systems Architecture; 3. Learning Objects; and 4. Computer Managed Instruction]. For example, the Learner Model (a person-centered database that can potentially track and manage everything an individual learns, knows, and does) offers fertile ground for innovation and extended functionality. The technical standard defines the data interchange format, a critical first step, but the potential functionality offers many good opportunities for innovation, especially dealing with improved learning and human knowledge acquisition. Proposals should be for new technology, not merely the application of existing technology.

PHASE I: Conduct extensive study and/or develop early prototype software of proposed technology for purposes of demonstrating technical feasibility, user benefits, and commercial marketability.

PHASE II: Complete development of proposed innovation, technology or system.

PHASE III DUAL USE APPLICATIONS: Product sales to commercial logistics market. Product sales to education, training, and performance-support markets. License agreement with DII COE for segmented products. Follow-on R&D contracts from government and industrial customers. Technical Demonstrations as part of military R&D programs.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Training is a major portion of O&S costs.

KEYWORDS: distance learning, distributed learning, learning technology, logistics, C2, learner model, student model, knowledge management, learning object, computer managed instruction, soldier

## TECHNOLOGY AREAS: Human Systems

**OBJECTIVE:** Develop and demonstrate a smart, video-rate response, electro-optic active ambient attenuator (EA3) for use in see-through head mounted display (HMD) systems. The attenuator material technology will improve the human systems interface of HMD systems by ameliorating the conditions which increase power consumption and reduce image contrast and quality. No existing material/device structure currently exists which can provide this capability.

**DESCRIPTION:** Current HMD electro-optic designs require high transmittance for see-through channel optics during low scene ambient conditions. This conflicts with the need for high display luminance/contrast during high scene ambient conditions (<10 kfc). Introduction of a video rate attenuator which incorporates scene/display luminance feedback controls will permit see-through HMD designs which do not depend on high display luminance to provide adequate image contrast under high ambient illumination environments (this is currently the case for Comanche, and other HMD systems). The ability to switch between high transmittance and low transmittance at both the pixel and bulk addressed level will establish a new capability for compensation of dynamic ambient illumination conditions. The resultant lower power display luminance requirements will reduce the HMD power consumption, and will also reduce the thermal signature and the users head borne heat load. Localized, small area bright source attenuation will improve threat and hazard detection in urban and battlefield environments.

**PHASE I:** Perform comparative study of candidate EA3 device materials and structures. The study shall, as a minimum, provide physical test data obtained from bulk material test cells. Functional samples of the of the candidate structures will be submitted to the Government for electro-optic characterization. These materials demonstration test cells will be capable of being driven at 60 Hz video rates, in order to define the material electro-optic performance suitability for HMD applications. The study will address such parameters as maximum transmittance state, maximum achievable attenuation level, temporal characteristics (t-on/t-off), and operating temperature range. Integrate Contractor and Government generated findings into final report of comparative device study, and deliver final report to Government.

**PHASE II:** Design, develop and deliver to the Government a functional EA3 demonstration unit which can be driven in both bulk (HMD field of view) & small (pixel & pixel block) area luminance attenuation modes. Ambient attenuation will be established via a closed feedback system between the ambient channel and the display and will provide for both manually regulated and auto-sensing/controlled attenuation. The electro-optic attenuator demonstrator will be integrated with a representative see-through/display channel which incorporates a functional miniature, high resolution display (640x480 monochrome, minimum). The demonstration unit will incorporate the required electro-optical control mechanisms, algorithms and feedback architectures required to modulate the attenuator material. The Phase II unit will serve to determine the ability of the material and device structure to meet the electro-optic performance requirements relative to military, see-through HMD systems applications. Delivery shall include any ancillary support equipment required to operate the EA3 demonstration unit such that the Government can operate the demonstration unit to perform an independent electro-optic performance evaluation of the device characteristics. Ancillary equipment not specifically funded under this effort will be returned to Offeror NLT 30 days after delivery to Government.

**PHASE III DUAL USE APPLICATIONS:** EA3 technology has strong commercial and Tri-Service potential for aviation HMD applications. To date, no see-through HMD systems meet the desired operational performance levels. This device technology can ameliorate the luminance and power conditions such that realistic HMD designs may be realized. Availability of this device technology will greatly increase the manufacturability of HMD systems which are capable of meeting military operational requirements. Further military and commercial use of this technology approach is possible as larger area devices become available for direct view applications. Potential military program beneficiaries include Land Warrior, Mounted Warrior, Air Warrior, Comanche, and Apache vision systems.

**OPERATING AND SUPPORT COST (OSCR) REDUCTION:** Ambient attenuation will result in lower display luminance requirements. Lower luminance translates directly into longer life for the displays & longer battery life for untethered systems. These factors result in lower system life cycle cost, and reduced operating cost. These cost savings are applicable to all see-through HMD systems.

**KEYWORDS:** Head Mounted Display, HMD, Electro-optics, Attenuator

## TECHNOLOGY AREAS: Human Systems

**OBJECTIVE:** Develop and demonstrate innovative backlight technologies for miniature Active Matrix Liquid Crystal Display (AMLCD) panels for use on military Head Mounted Displays (HMDs) and weapon sights. These technologies should produce a more efficient, lower power backlight for both low and high brightness applications. To date, little research has been performed to produce an efficient and optimized miniature AMCLD backlight.

**DESCRIPTION:** The military is currently in the process of inserting flat panel displays such as AMLCDs into military HMDs and weapon sites. These applications require miniature (<1.5" diagonal) high resolution (> 320 x 240) displays with a nominal LCD pixel pitch of 12 to 15 micro-meters. Some aviation see-thru HMDs require AMLCDs with a resolution of 1280 x 1024 and output luminances on the order of 1,500 to 2,000 ft-L. Current backlight sources such as remote arc-lamps are bulky and require high power consumption in order to produce enough light. High power backlights also possess a larger heat load and require complicated heat dissipation techniques. To date, no backlight has been fabricated to meet the luminance, size, power and heat goals. Innovative research is required to examine new techniques for meeting all of these goals. AMLCD displays intended for dismounted soldiers require lower luminance (approximately 100-200 ft-L) and also require low power consumption (including backlight). Low efficiency backlights require the soldier to carry more batteries and thus more weight. More efficient, lower power backlights could solve both the aviation and the dismounted soldier display backlight problems.

**PHASE I:** Perform comparative study of candidate backlight technologies. This study should examine source and coupling technologies for both the low and high brightness applications. The study shall as a minimum, include physical test data obtained from measurements of candidate approaches. Functional samples of the candidate approaches shall be submitted to the Government for evaluation.

**PHASE II:** Develop and demonstrate multiple functional backlight technologies and integrate them onto a monochrome or color AMLCD display with a minimum resolution of 640 x 480 active pixels. Functional samples of the candidate devices (backlight, AMLCD display, drive electronics) shall be submitted to the government for evaluations. The candidate devices should be capable of being driven by a computer or video generator via standard VESA 60 Hz or 72 Hz video signals using a 15-pin VGA analog signal connector. Candidate backlight technologies will be characterized by performance criteria such as power consumption, heat dissipation, power efficiency, luminance uniformity, and motion video artifacts of the AMLCD caused by the backlight.

**PHASE III DUAL USE APPLICATIONS:** An innovative power efficient backlight has both commercial and military applications. The candidate backlight could be integrated to a military miniature AMLCD and be demonstrated on a military aviation or dismounted soldier HMD or weapon sight. Commercial demonstration could be performed by utilizing the backlight in low power, high performance, AMLCD display applications such as on cellular phones, video cameras, and portable televisions.

**OPERATING AND SUPPORT COST (OSCR) REDUCTION:** Innovative backlight technologies will lower the military operating costs for military systems in several ways. The more efficient/lower power backlight will require less power and allow the dismounted soldier to operate longer and require fewer batteries during operational use. Innovative backlights should be smaller in size, possess fewer parts than current backlights, and increase the display system's reliability.

**KEYWORDS:** AMLCD, Head Mounted Display, HMD, Backlight

A99-144      **TITLE:** Dual-voltage, Multiconfigurabe Nonrechargeable Battery Design with Adapter

**TECHNOLOGY AREAS:** Information Systems Technology

**OBJECTIVE:** Increase the ability of existing Army lithium prismatic shaped battery types to meet future equipment battery footprints and decrease the chances for future battery type proliferation in the logistics system.

**DESCRIPTION:** Dual voltage, multi-configurable battery design concept that can be retrofitted to existing prismatic Army Lithium batteries and allow the design (with proper adapter) to mimic original battery and without the adapter, form four additional dual voltage prismatic shaped batteries. Successful design will allow the Army to replace one original battery with one that can form four physically distinct battery types, each capable of providing two electrical configurations and with an adapter, the design can mimic the original battery.

**PHASE I:** Propose a dual voltage, multiconfigurabe battery design concept that can be inserted into a BA-5847/U lithium battery configuration. The design with a proper adapter will mimic the BA-5847/U battery (6 VDC, 50 watt-hour and 3 ampere capable) and without the adapter will fold to form four distinct prismatic shapes and each shape can operate at a 6 VDC or 12 VDC electrically. The proposed design must account for mechanical issues such as ruggedization, water resistance, electrical and mechanical connections between modules, optimal packaging of electrochemical cells to maximize battery energy



and power capability within the size and weight constraints of a BA-5847/U type battery. Produce 15 prototype mock ups of concept.

PHASE II: Set up and manufacture 400 dual voltage multiconfigurables with proper adapter to mimic the BA-5847/U type battery. The batteries shall meet the performance and safety requirements of MIL-PRF-49471(ER).

PHASE III DUAL USE APPLICATIONS: Apply design and manufacturing techniques for military and commercial nonrechargeable and rechargeable batteries.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The dual voltage multiconfigurable battery design concepts will help simplify future battlefield logistics and decrease the chances for future battery type proliferation by making existing Standard Army prismatic batteries multiconfigurables to meet future equipment battery needs and still retain the ability to operate in legacy equipments.

KEYWORDS: battery, dual voltage, multiconfigurable

A99-145 TITLE: Speech Intercept Intelligibility for Spectrum Supremacy

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Improve the intelligibility of intercepted speech communications over tactical radios for spectrum supremacy situation intelligence processing.

DESCRIPTION: The intelligence community is interested in extracting tactical situation knowledge of current and planned enemy activities from automated monitoring of battlefield radio communications. Natural language understanding, language identification, language translation, and key words spotting are emerging technologies, which can be applied in this quest for relevant information. The limiting factor in the successful application of these emerging language based interpreters is the poor quality of the speech captured from these tactical radio emissions in a battlefield environment. An innovative method for improving the speech quality of these tactical radio intercepted transmissions is the underlying research needed. This research should lead to dramatic improvement in pre-processed "clean speech" for subsequent language algorithm application. The key is to develop a concept for accurately extracting the captured speech from the severely degraded transmission intercept in a way that is the most beneficial for natural language algorithm performance.

PHASE I: Develop an innovative methodology to improve the performance of natural language algorithms for degraded tactical radio transmitted speech. Continue progress in the research of speech intelligibility algorithms that can accurately extract speech in the presence of signal to noise ratios of minus 10 dB or less. Demonstrate and quantify the improvement in speech intelligibility for degraded tactical radio intercepted communication and the natural language algorithm(s) post processing success. Show the feasibility of applying the low signal to noise ratio speech extraction remedies to low power and processing limited mobile tactical radio receivers.

PHASE II: Demonstrate the successful natural language identification and context understanding post processing for degraded tactical speech intercepts. The natural language identification and context understanding algorithms are to be integrated with next generation tactical radio speech processing schema to effect a processing efficient and low power consumption solution. The effectiveness of the real-time speech intelligibility enhancement shall be demonstrated using only the single tactical radio processor resource, to show power consumption savings obtained by merging duplicative speech processing and memory requirements. These prototypes will use recorded and live intercept voice transmissions containing typical fading and multi-path phenomena.

PHASE III DUAL USE APPLICATIONS: Automated natural language interpretation and understanding processing represents the preferred next generation interface between humans and their supporting electronic devices. Applications for this natural language interface include personal data assistants, computers, controls and an intuitive interface for appliances, radio, cell-phones, vendor kiosks, web-site browsers, information fusion and decision aids. Improved speech intelligibility processing for degraded speech transmission will provide wider user acceptability of the automated natural language technology in a wide range of consumer products and services.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Automated intelligence monitoring and language understanding represents a significant breakthrough in this human labor intensive task. Reductions in required personnel of 10 to 1 are predicted as a result of the technology implementation for electronic warfare and intelligence warfare missions. This automated technology represents a practical solution to the surveillance of the ever increasing bandwidth use which necessitates innovative and automated solutions to achieve spectrum supremacy.

REFERENCES: IEEE 1997 International Frequency Control Symposium, "New Prospects for Acoustic Sensors". Experimental Psychology, Oct 1998, "The Role of Lexical Information in Syntactic Ambiguity Resolution. Architectural Acoustic Principles and Practices, Cavanaugh; Wilkes, Oct 1998. DRA Laboratories, Sarasota, FL, "MLSSA Speech Intelligibility Measurements. Speech Technology "Detecting the Goats", June 1998, "How Speech Can Be Used for Multi Language Applications", Aug 1998, "Beyond recognition to Understanding" Oct 1998.

KEYWORDS: natural language identification, speech intelligibility, tactical radio communication

#### **U.S. Army Construction Engineering Research Laboratory (CERL)**

A99-146 TITLE: Asbestos Neutralization by In-situ Chemical Digestion

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The objective is to develop and test innovative in situ chemical digestion of asbestos in asbestos containing materials (ACM), using acids such as fluorosulfonic acid, which have been used in Army/DoD buildings and structures.

DESCRIPTION: In the past, asbestos containing materials have been used in DoD buildings and structures for pipe insulation, boiler/tank insulation, spray on fireproofing, plasters, vinyl asbestos floor tiles, roofing felts, and in transite boards. Currently, in place management is recommended since removal is not affordable. However, this merely postpones the abatement until major rehabilitation or demolition takes place. The cost of asbestos removal is prohibitive and cheaper technology for abatement is needed. Current techniques for removing asbestos containing materials (ACM) require the construction of airtight barriers, labor intensive scraping of the ACM and costly environmental and worker protection. Development and testing of an in situ chemical digestion process for ACM will greatly reduce the cost of asbestos abatement. The United States Environmental Protection Agency (EPA) introduced regulations to minimize building occupants' exposure to asbestos dust derived from building materials. On November 28, 1990, the Asbestos School Hazard Abatement Reauthorization Act (ASHARA) was enacted to amend certain portions of Asbestos Hazard Emergency Response Act (AHERA) to extend certain elements of the school program to public and commercial buildings. From the earliest days of this technology, most field engineers have defined asbestos abatement to include one or a combination of: removal, enclosure, encapsulation, and management in place. Basic concepts, which employ fluoro acid decomposing agents, have been demonstrated by the Brookhaven National Laboratory. However, further development of this chemical digestion technology is needed for neutralization of ACM in insulation in Army/DoD buildings and structures.

PHASE I: Explore and establish the feasibility of developing innovative chemicals for in situ digestion of ACM. Previous technology (as shown in references) has used fluorosulfonic acid to digest asbestos containing materials in spray on fireproofing for steel structural components of buildings. The process should be applicable to ACM used for insulation in Army buildings. The methodology will include formulating and testing chemicals that are known to digest asbestos minerals in the serpentine group. It is expected that when the treatment is done, it will no longer be a regulated material and will contain less than 1 percent fibers, which is the EPA's definition of non-asbestos materials. The methodology shall meet the following criteria: (1) Develop ACM digestion chemicals that will dissociate chrysotile asbestos into non-regulated components, (2) Develop binding agents that will bind the non-regulated components to form an environmentally benign solid, (3) Develop process to increase reaction rate ACM digestion chemicals, (4) Develop method of in situ application of digestion chemicals to chrysotile in ACM in typical geometric configurations where ACM has been used in the past, e.g., pipe insulation, (5) Develop process by which binding agents are applied in situ to typical geometric configurations in which the ACM has been used in the past, e.g., pipe insulation, (6) Develop process for safe removal of environmentally benign solid product, and remaining chemical digestion and binding agents from the point of application.

PHASE II: Perform development of the process and testing in the field.

PHASE III DUAL USE APPLICATIONS: This technology represents a high payoff potential for DoD buildings and structures as well as commercial buildings, schools and hospitals. Basic concepts have been demonstrated by the Brookhaven National Laboratory. There is excellent potential for commercialization.

OPERATIONS AND SUPPORT COST REDUCTION (OSCR): The DoD owns more than 2 billion square feet of buildings and structures which have some ACM. It is estimated that the cost to the DoD for asbestos inspection, training, in place management, and abatement will exceed \$ 1 billion. In situ digestion by chemicals has the potential of cost avoidance of 20 percent, or \$200 million.

KEYWORDS: asbestos, digestion, buildings, chrysotile, gypsum

REFERENCES: T. Sugama, R. Sabatini, L. Petrakis, "Decomposition of Chrysotile Asbestos by Fluoro-sulfonic Acid", Industrial and Engineering Chemistry Research, Vol. 37, p. 79-88, 1998. J. A. Hriljac, C. Eylem, Q. Zhu, R. Sabatini, L. Petrakis, R. Hu, J. Block "Use of X-ray Powder Diffraction for Determining Low Levels of Chrysotile Asbestos in Gypsum-Based Bulk Material: Use of a Synchrotron Source", Analytica Chimica Acta, Vol.350, p.221-229, 1997. R. Hu, J. Block, J. A. Hriljac, C. Eylem, L. Petrakis, "Use of X-ray Powder Diffraction for determining Low Levels of Chrysotile Asbestos in Gypsum-Based Bulk Material: Sample Preparation", Analytical Chemistry, Vol. 68, p.3112-3120, 1996.

A99-147                      TITLE: Magnetic Fluxgate Micro-electromechanical Systems (MEMS) Sensor for Structural Integrity Monitoring Capabilities

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop a sensor for measuring magnetic flux on the surface of structural components using micro electromechanical systems (MEMS) technologies. The sensor must be small (< 5 mm length) and easily attached to the surface of a structural component by an adhesive bond. The sensor must be capable of detecting flux readings of 0.0001 Gauss or less. The technology should be developed such that an array of sensors can be manufactured in a sensing "grid" or "patch" that can be attached to the surface of a structural component.

DESCRIPTION: Recent work shows that tagging of structural components with a magnetostrictive phase yields a structural material that emits a magnetic flux proportional to the applied loading on the structure. Locally elevated stresses around cracks and other forms of damage produce locally elevated readings in magnetic flux for these materials. As such, the magnetic flux on the surface of tagged structural components can be used to monitor the structural integrity of these components. Development of micro fluxgate sensors based on MEMS technology provides the capability to obtain continuous monitoring of surface and/or subsurface magnetic flux, detailed spatial resolution in order to locate precisely the structural damage, and the capability to utilize a host of low cost magnetostrictive tagging materials. MEMS technology is based on photolithographic patterning. It is therefore capable of generating fine geometric features and precise control of device characteristics. In addition, the fabrication process is mass predictable, making it suitable for realizing arrayed devices. Electroplated Permalloy material (with 80% Ni and 20% Fe contents) has been under development at research institutes. It offers material properties desirable for the application in flux gate sensors (e.g. high permeability on the order of 4500).

PHASE I: Develop and demonstrate the manufacturing techniques to fabricate a micro fluxgate sensor capable of detecting magnetic flux readings on a laboratory specimen of magnetostrictive tagged polyester composite structural material. Direct comparisons with a Hall-effect sensor will be made. A simplified fabrication process based on electroplated Permalloy material and evaporated metallization will be developed. The process is expected to require reduced processing time and complexity compared with state of art.

PHASE II: Develop sensor "grids" of micro fluxgate sensors to be bonded to laboratory and prototype tagged structural materials. Direct comparisons with existing magnetic flux measuring systems will be made.

PHASE III DUAL-USE APPLICATIONS: Because the technology is applied to basic structural materials, it is directly transferable to all other branches of the federal government and to the entire civilian sector as well. Facilitating the use of composite materials in infrastructure applications has the potential for major cost savings in U.S. construction and maintenance industries. For example, the technology developed for the fluxgate sensor will enable high-density array of magnetic leakage (ML) sensors for non-destructive evaluation (NDE) of structures. Current ML NDE units contain only single units and are bulky. It is impossible to detect small defects with high precision. The project under development is expected to yield technology that will enable this and other revolutionary devices with broad applications. The magnetic MEMS is generally useful for a number of sensor and actuator applications. Examples include micro actuators for active optical fiber alignment in advanced communication systems, and magnetic systems for controlling biological entities in micro fluidic systems. This program is expected to provide the principal researchers with an opportunity to develop basic understanding and practical technologies for realizing high-performance magnetic sensors and actuators.

OPERATIONS AND SUPPORT COST REDUCTION (OSCR): The DOD owns more than 2 billion square feet of buildings, most of which have inadequate structural integrity monitoring. Self-monitoring structural systems offering the potential for assuring the structural adequacy of a facility with less on-site inspections can save millions of dollars in annual inspection costs. Additionally, lightweight, self monitoring, composite systems offer the field Army the potential to fabricate self assessing gap crossing systems to insure safe gap crossings.

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KEYWORDS: sensor, structural integrity monitoring

A99-148 TITLE: Artificial Intelligence (AI) Technology for Identifying Pavement Defects From Visual Image Data

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and test Artificial Intelligence (AI) algorithms capable of identifying pavement distresses and severity levels from digital image data as per the Micro PAVER manual.

DESCRIPTION: Infrastructure management, especially in the area of pavements, is gaining higher priority in an area of sustainable systems. Manual pavement surveying techniques are often prohibitive in terms of time and cost. The ability to quickly gather and analyze pavement inspection data would enormously reduce the costs of pavement surveys. The use of video technology is becoming accepted for use in pavement distress inspection. Video inspection data, in the form of 35mm film, can be transformed into digital image data. The digital image data is the basis for distress identification algorithms. The U.S. Army Construction Engineering Research Laboratories (CERL) has conducted a limited amount of research in which AI algorithms have been developed for identifying cracks in asphalt pavements. First, the image is converted into a photographic negative. The algorithms manipulate the image format to separate the crack footprint from the general image. Pixels are evaluated based on a number from 0-255, representing 256 shades of gray. The pixels in the image are adjusted based on three types of algorithms: point processes, area processes, and geometric processes. Point processes scan the image and use the pixel value at each point to compute a new value at that point. The area process uses information from neighboring pixels to modify pixel values or assert the existence of some property of the neighborhood. A geometric process changes the arrangement of the pixels. The patterns of pixel values in the filtered image can be identified as objects representing crack types. The distress information is automatically catalogued and entered into a database compatible with the Micro PAVER for Windows program developed by CERL.

PHASE I: Develop and test the ability of current or state of the art algorithms to correctly identify different crack types in pavement. The algorithms should be consistent with the technology developed in the AutoPAVER program outlined in CERL Technical Report M-90/15. The algorithms will improve the current method of manipulating pixel data and identifying crack types in single or multiple frames. Expand the capabilities of the algorithms to accurately establish the severity levels and quantities of the individual cracks. Classification for image elements must be consistent with current PCI distress measures. No technical risk exists for identifying crack types, however a risk does exist with determining severity levels.

PHASE II: Develop and test algorithms capable of identifying additional surface distress types and their respective severity levels and quantities. These include, but are not limited to patching, bleeding, weathering, potholes, bumps, and depressions. Develop software that will integrate individual algorithms for the different distresses. The software will enable the algorithms to operate independently of one another to determine distress information from digital image data. However, the software will examine the type and location of the distresses, and eliminate any duplication of distress information. The software will build and manage the information database. The software must operate as both a module of the current Micro PAVER program or as a stand-alone program that can be launched from within Micro PAVER. In addition, software should be designed to enable the simple integration of analysis algorithms for other infrastructure systems.

PHASE III DUAL USE APPLICATIONS: The technology developed here can be applied to a variety of inspection-oriented management areas. The current development of an automated inspection interface and the investigation of video inspection techniques for use in Micro PAVER will complement the artificial distress identification technology. Additional infrastructure systems, such as sewers, can benefit from the developed technology. The technology is applicable to the civilian infrastructure management sector. The technology could account for a potentially significant cost saving for military

installation managers, municipal infrastructure managers, while boosting the competitiveness of the U.S. civil engineering consulting industry.

**OPERATIONS AND SUPPORT COST REDUCTION (OSCR):** With a Plant Replacement Value of over \$200 billion for Army installations, it is clearly evident that the life of current facilities needs to be extended through careful and comprehensive maintenance and repair. Engineered Management Systems (EMS), such as Micro PAVER, help achieve this goal. A controlled test of PAVER realized a cost avoidance of nearly 50%. However, manual pavement inspections are lengthy and costly, often taking several months. Video inspection technology enables several hundred lane-miles of road to be inspected in just a few days. The addition of the technology described here would reduce the analysis time of the video data from weeks to days. The true savings have not been accurately measured, but are clearly substantial.

**KEYWORDS:** Artificial Intelligence, Micro PAVER, automated inspection

**REFERENCES:** Ginsberg, Mark D., Shahin, M.Y., Walther, Jeannette A., "AutoPAVER, A Software Package for Automated Pavement Evaluation," USACERL Technical Report M-90/15, USACERL, 1990. Shahin, M.Y., Pavement Management for Airports, Roads, and Parking Lots, Chapman & Hall, New York, NY, 1994.

### **U.S. Army Chemical Biological Center of Excellence (CBCOE)**

A99-149      **TITLE:** Self-contained Surface Bio-sampling Apparatus

**TECHNOLOGY AREAS:** Chemical/Biological Defense and Nuclear

**OBJECTIVE:** Design and construct a self contained surface biosampling device for swabbing surfaces and delivering bacteria, virus, and toxin in a 20 ml liquid sample.

**DESCRIPTION:** Biodetection systems require a liquid sample containing biothreat agent for analysis. Field deployed systems utilize large air impactors to force aerosolized bioagents into liquid phase. A need exists for a self-contained device which can be rubbed against a surface to remove deposited biologicals and transfer it to a sealed collection vial with minimal exposure of personnel during sampling. **GENERAL DESCRIPTION OF THE CURRENT SITUATION:** Packages of biological surface sampling sponges exist that were developed for the food industry and medical swabbing devices immersed in saline solutions are also available. Because it is necessary to swab an area of at least 1 meter square to extract enough bioagent these objects do not deliver enough fluid to precipitate effective swabbing and the stick swabs do not possess enough surface area to efficiently pick up biologicals. The current systems may also contain many parts and bags, which are difficult to handle in a hostile environment. Protective garb also makes manipulation of tiny pieces, tearing of bags, and handling of vials difficult. The construction of a device which contains a universal biological surface sampling material coupled with a sterile pre-measured liquid sample (such as a liquid filled ampule) would be the best solution for this need.

**PHASE I:** Design a strategy for the construction of a device capable of sampling biologicals from 1 square meter of benches, machinery, and other similar surfaces. The device should be easily opened and implemented by personnel in chem/bio protective garb. The design should enable the transfer of the maximum amount of surface biologicals into a twenty milliliter solution of buffer free of debris larger than ten microns. The final liquid sample should be transferred into a sealed collection vial for delivery to a biodetection device without exposure of soldiers. Deliverables for phase I include detailed design drawings, estimated costs, and documented studies on swab selection. Swab studies should involve testing the effectiveness of the swab material in transferring known amounts of the simulants ovalbumin, MS2, and Erwinia herbicula. Substitutions for these simulants are acceptable as long as a simulant is chosen for a toxin, a virus, and a bacterium. Accommodations should be included so that the devices can be marked and transported without contamination of personnel and adherence to chain of custody doctrines.

**PHASE II:** During phase II proto-types should be constructed and tested in-house. The testing should involve simulants at various known concentrations on three different surfaces. Data should be analyzed by how much bioagent was removed and transferred, ease of use, and should be coupled to a corroborating biodetection scheme such as ELISA or colony plate counting. ECBC may be approached to coordinate the biodetection aspects if the SBIR facility is not capable of testing at this level. The results should be used to modify the device to correct any deficiencies discovered during the first part of phase II. Following these studies the contractor should produce a small number of units for field testing with ECBC and the technical escort units. Data will be shared with the SBIR company and used for further improvements.

**PHASE III DUAL-USE APPLICATIONS:** Develop and commercialize this technology for application in the food industry and medical environments. There are additional commercial markets in domestic preparedness and overseas efforts in biological verification. Key words: biodetection, surface sampling, biological sampling, swab

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The need to couple biotetection assets to surface sampled objects is a pressing need. Air impactors are not readily available and may not always be the best choice for some scenarios. This field hardy, single use device will fill a vital gap in biotetection.

#### **U.S. Army Missile Research, Development, and Engineering Center (MRDEC)**

A99-150                      TITLE: Novel Imaging Techniques for Compact Aerial Vehicles

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: The objective of this topic is the development and application of novel imaging sensors in space/weight critical environments such as that of a compact aerial vehicle. In addition to military uses, such technology would be applicable to many commercial uses such as law enforcement and property protection systems.

DESCRIPTION: This topic seeks innovative solutions to imaging sensors which can be carried aboard a compact, disposable aerial vehicle. Such a vehicle is a small (14"-24" wingspan), lightweight (1/2-3/4 lb. total payload), low cost, disposable (i.e. non-recoverable) vehicle capable of flying autonomously/near-autonomously for sustained durations (.5-1 hour). To preserve size, weight, cost, and power, all subsystems on the aircraft will typically perform multiple functions. The functional requirements envisioned for this imaging sensor system are: a) Vehicle navigation to a potential target area without reliance on GPS or other jammable navigation aids. b) Target search with a resolution of 6.0 line pairs or better on a tank sized (3 meter by 3 meter) target at an altitude of 300 meters. A single pass over the target area searches an area 1 km wide (i.e. field of view of approximately 120 degrees). Datalink the imagery to an operator on the ground using at most 2 megabits/second data rate. c) Perform target location to an accuracy of 80 meters CEP. d) Perform vehicle orientation (pitch, roll) (eliminates need for pitch, roll gyros). e) Perform the above operations during day and night (1/4 moon) conditions. f) Total airborne system weight of 150 grams and total power of <2 watts for all imaging system components and airborne image processing required to meet the above functional requirements. Traditional imaging sensor systems cannot meet the above requirements within the constraints of a compact aerial vehicle. This topic seeks to develop novel imaging sensors and associated novel processing algorithms/hardware achieve the above requirements.

PHASE I: The contractor shall perform a technology search for components which could be combined into a highly integrated/miniatuized imaging sensor system which meets the above functions and requirements. The search shall consider all system components such as lenses, mirrors, scanning mechanizations, image processing/compression algorithms, light sensors, etc. The contractor shall propose an implementation concept for integrating the components together into a compact aerial vehicle imaging sensor system which meets the above functions and requirements.

PHASE II: The contractor shall implement the imaging sensor design proposed in Phase I.

PHASE III DUAL-USE APPLICATIONS: Commercial applications for this technology might be found in the surveillance and law enforcement industries. The miniature, low power imaging sensor developed under this topic would provide an ideal covert imaging sensor that could operate remotely for extended periods of time.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Increased reliability brought about by this technology would fit within OSCR by reducing the number of spare parts required for system upkeep. This would also reduce maintenance costs over the system life.

KEYWORDS: Infrared, Charge Coupled Device (CCD), Imaging sensors, low light level

A99-151                      TITLE: Alternative Communications for Nonline-of-sight Applications

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Wide bandwidth communication systems employing traditional RF methods are limited by multipath propagation effects and time dependent fading. The objective is to advance the state-of-the-art of a modulation scheme which spreads narrow pulses over an extremely broad bandwidth known as impulse radio. This technique is covert, jam resistant, utilizes low power, is immune to multipath effects (excellent clutter rejection), and will not interfere with or degrade the performance of another narrowband user in the electromagnetic spectrum. While the primary MRDEC application will be to transmit digital video to enable steering a teleoperated ground platform for delivery of weapons payloads, other potential application areas include missile guidance links for non line-of-sight environments (low altitude trajectories), and transmission of sensor data from

autonomous platforms. Impulse radios are predicated on the ability to generate very narrow pulses with extreme precision and low jitter. However, breakthroughs in SiGe heterojunction transistors (SiGe HBTs) may lower the cost of the time delay generator to enable commercialization of impulse radios.

**DESCRIPTION:** Although ground robotic platforms have enormous potential for remote delivery of weapons payloads, ordnance disposal, logistics resupply and surveillance and reconnaissance, current communications to steer the vehicle are limited primarily to RF transmission of analog video over at most a few kilometers (km). Proponents of ground robotics within the Army have expressed a desire (through Operational Requirements Documents) to increase the communications range, i.e., the separation distance between the operator and the vehicle, to at least 10km, with 40km desirable. This technology would enable digital video to be transmitted to an airborne relay such as mini-UAV and downlinked to an operator at a ground station. In addition to steering the vehicle, freeze frames of the video could be annotated at the ground processing station for transmission to a rear-based tactical operations center along the tactical internet.

**PHASE I:** Explore the feasibility of transmitting digital video in free space (10 to 40 km) using impulse radio by examining the tradeoffs between bit error rate (BER) as a function of noise, power requirements, and modulation. Consideration must be given to how the receiver will be synchronized with the transmitter for transmission in the free-space environment. In order to address these issues, some research into digital communication theory may be included that focuses on but is not limited to synchronization aspects such as chaotic pulse encoding and appropriate analytic bit error probability expressions.

**PHASE II:** The deliverable prototype will be a set of digital video cameras with impulse radio transceivers mounted on the ground robotic platform, airborne relay, and operator control unit (ground processing station). The airborne relay is necessary because the impulse radio is a line-of-sight technology. Several digital video cameras will need to be multiplexed to achieve remote guidance of the ground robotic platform along with surveillance video, telemetry, and precise acquisition and tracking of the airborne relay. The Phase II effort should include a demonstration of this technology, with the SBIR contractor choosing the demonstration site. A helicopter may be used as the airborne communications node with an impulse radio transceiver mounted on it to relay the digital video signals from the ground robotic platform to the operator control unit(OCU). The separation distance between the robotic platform and the OCU will depend on test area restrictions. Note that digital video is preferred over analog video to be consistent with the vision of the future battlefield. Digital compression methods must also be utilized. This effort will directly support the MRDEC technology base program known as "Robotic Applications for Modular Payloads".

**PHASE III DUAL-USE APPLICATIONS:** Hand held impulse radios for voice applications have been successfully demonstrated for military use at Battle Command Battle Lab - Ft. Gordon, GA. The characteristics of impulse radios such as immunity from multipath, efficient use of the spectrum to overcome frequency management problems, low power, and extreme covertness (receivers synchronized to receive pulses generated in picosecond timeframe) are attractive to both the military and law enforcement agencies. Another military application might be the transmission of sensor data from an autonomous robotic platform to a tactical operations center for situational awareness and reconnaissance purposes. Research and development from this effort (waveforms, application specific integrated circuits) might influence developments in impulse radar such as motion-sensing radar to image through obstacles (law enforcement, firefighters) and the development of weather radar able to instantaneously image storms. The potential commercial market of the digital video system is law enforcement for surveillance.

**OPERATING AND SUPPORT COST (OSCR) REDUCTION:** Accurate long range target acquisition decreases maneuver time and also conserves fuel and batteries. Also, acquiring accurate battle damage assessment saves ordnance.

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KEYWORDS: impulse radio, ultrawide bandwidth signals, radio frequency communications, ultrawide RF, silicon germanium heterojunction transistor, spread spectrum technology

A99-152                      TITLE: 2D High-speed Bipolar Optical Modulator Array

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environments

OBJECTIVE: The Objective of this task is to investigate the utility and feasibility of encoding bipolar data in optical image processing systems. While there are devices that can meet some of the design criteria, there is none currently available that can meet the high resolution, high frame rates with bipolar modulation. A device that could meet all the required specifications would improve the speed and accuracy of image processing systems. These improvements would have applications in imagery analysis and in machine vision for quality control and manufacturing processes.

DESCRIPTION: Current optical image processing systems require a spatial light modulator (SLM) to write information onto the light. The characteristics of the SLM are a limiting factor in the system performance. A modulator with scalar bipolar modulation characteristics would allow implementation of more powerful filtering techniques; improving overall system performance. To be truly useful, a Bipolar SLM should have the following characteristics. Each sub-region or pixel should modulate the amplitude of the optical wavefront according to the following equation:  $t = m A \exp(iq)$ . where;  $A$  is maximum transmittance (or reflectance) of the device;  $0 < A \leq 1$ .  $m$  is the modulation factor;  $-1 \leq m \leq 1$ .  $q$  is the modulation phase angle; a constant. Each pixel is individually controlled by a signal, represented by  $m$ , which determines the transmission (or reflection) of that pixel. Optical active area must be greater than 80%. Modulation resolution,  $\Delta m < 1/125$ . Frame rate of operation is a minimum of 4 kilohertz. Spatial resolution in each dimension must be at least 10 line pairs per millimeter. Also, the array must have acceptable uniformity of the following parameters, across all pixels:  $A$ ,  $q$ , and  $\Delta m$ .

PHASE I: The goal of Phase I would be to design a device to perform bipolar scalar modulation on an individual pixel basis as described above. The design should be for a two-dimensional (2D) array with 128 X 128 sub-regions or pixels. The design should also be scalable up to 1024 X 1024 sub-regions or pixels. If starting with a new design, detailed plans would be made available for review. If the design leverages off existing hardware, a small-scale demonstration would be required.

PHASE II: The goal of Phase II would be to fully demonstrate the device designed in Phase I. This would include the manufacturing and delivering of a 128 X 128 prototype device for testing and evaluation. Support hardware and software needed to operate the device would also be included in the deliverables.

PHASE III DUAL-USE APPLICATIONS: The goal of Phase III would be to demonstrate the two-dimensional high speed bipolar optical modulator array for use in machine vision and manufacturing applications.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Military systems which incorporate image processing hardware serve as an aid to the soldier by reducing his workload and improving his efficiency. Not only will the improved speed and accuracy of these systems further reduce the demands on the soldier, but it would open doors to new applications which may serve him in the future.

REFERENCES: J. Kirsch, B.K. Jones, J.J. Booth, J.N. Duffey and J. A. Loudin, "Optical aided target recognition system," Materials, Devices, and Systems for Optoelectronic Processing, Bahram Javidi and John Neff, ed., Proc. Soc. Photo-Opt. Instrum. Eng. 2848, August 1996.

KEYWORDS: bipolar filters, spatial light modulator, optical signal processing, electro-optical devices

A99-153                      TITLE: Enhanced Scramjet Combustion

TECHNOLOGY AREAS: Space Platforms

OBJECTIVE: To develop innovative models for the basic physical and thermochemical processes coupling acoustics and combustion in multi-phase, chemically reacting, supersonic flows.

DESCRIPTION: All too often the theoretical potential of airbreathing missiles - scramjets, ramjets, and ducted rockets - are not realized because of the inherent failure to fully mix fuel and oxidizer streams within the geometric limits of these vehicles.



Practical designs to date for ramjets and ducted rockets have required compromises in operating conditions (e.g. air-fuel ratios far greater than stoichiometric) and hardware (e.g. flame holders) which greatly increase the complexity of the vehicles while adding significantly to the performance penalties. Scramjets remain beyond the reach of practicality largely because of the extreme difficulty in mixing, reacting, and maintaining supersonic flows. One innovative and as yet unexplored technique to remedy this inherent short-coming is through acoustic resonance, i.e. to acoustically enhance multi-stream mixing and, therefore, combustion with high frequency waves. However, the design, development, and validation process for acoustic drivers to enhance mixing and combustion has a very low probability of success without a comprehensive first principles based physical and thermochemical model which can couple acoustics and combustion for multi-phase, chemically reacting flows. State-of-the-art computational fluid dynamics models for multi-phase, chemically reacting flows could serve as the foundation to build such a design tool for acoustic enhancement devices; however, significant advances must be achieved. For example, the computational fluid dynamics, that is solution of the time-dependent Navier-Stokes equations on unstructured grids, must be fully coupled with the aero-acoustics to adequately resolve the high frequency phenomena. Also, the chemistry must be turbulent, not laminar as is currently the state-of-the-art, and the turbulence/chemistry interactions must be integral to an advanced nonlinear turbulence framework with compressibility and temperature/species fluctuation capabilities. Clearly, new, innovative, and improved approaches are needed.

PHASE I: Phase I proposals must demonstrate (1) a thorough understanding of the Topic area, (2) technical comprehension of key acoustic-combustion interaction problem areas, and (3) previous computational fluid dynamics experience in modeling multi-phase, nonequilibrium gas-particle, chemically reacting flows with a computational fluid dynamics code possessing those capabilities. Technical approaches will be formulated in Phase I to address each of the key problem areas for inclusion into computational fluid dynamic models. At least one innovative, meaningful demonstration of acoustic-combustion interactions will be proposed and a flowfield solution produced with the advance computational model during Phase I to assess the potential for Phase II success.

PHASE II: The model improvements formulated in Phase I will be finalized, documented, coded, and incorporated into an existing Government computational fluid dynamics code. The improved computational fluid dynamics model will be run blind for a hypersonic scramjet test case for which detailed flowfield and body force/moment data will be available to demonstrate the advanced capabilities for analyzing and modeling acoustic-combustion interactions.

PHASE III DUAL-USE APPLICATIONS: This technology is directly applicable to advanced propulsion techniques for commercial applications such as high speed supersonic transports and single stage to orbit launch systems.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The SBIR research topic entitled "Enhanced Scramjet Combustion" is oriented toward fundamental research of basic physical phenomena with direct application to mission objectives and any association with OSCR issues will be incidental.

#### REFERENCES:

1. Ishiguro, T., et. al., Proceedings of the 8th NAL Symposium on Aircraft Computational Aerodynamics, 1 November 1990.
2. Kenzakowski, D.C., et. al., "Analysis of Ducted Rocket Flowfields," Proceedings of the 1996 JANNAF Combustion Subcommittee and Propulsion Systems Hazards Subcommittee Joint Meetings, Naval Post-Graduate School, Monterey, California, 4-8 November 1996.
3. Gerlinger, P., et.al., "Numerical Investigation of Hydrogen Strut Injections into Supersonic Air Flows," 34th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, 12-15 July 1998, Paper No. AIAA-98-3424.
4. Kanda, T., "Simulation of an Airframe-Integrated Scramjet Engine," 34th AIAA/ ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, 12-15 July 1998, Paper No. AIAA-98-3427.

KEYWORDS: accoustics, combustion, scramjet, ducted rocket, ramjet, computational fluid dynamics, propulsion, modeling

A99-154 TITLE: Demonstration of Steerable Array Antenna using Micro Electro Mechanical Switches (MEMS) Technology

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: MicroElectroMechanical Switches (MEMS) have recently begun to show great promise in the area of true time delay steerable array antennas. This work appears to be reaching the critical mass necessary to begin experimental development/demonstration outside the laboratory. The objective of this topic is to acquire a MEMS based beam steering system capable of controlling the true time delay array antennas currently proposed for the next generation Army air defense radars, Federal Aviation Administration (FAA) air traffic control radars, commercial weather radars, and wide bandwidth military communication systems.

**DESCRIPTION:** The goal of this effort shall be to design fabricate, and test a two dimensional, steerable array including the beam steering equipment. The array shall be steerable in both azimuth and elevation. The beam steering architecture shall be MEMS based, true time delay steering capable of supporting waveforms with instantaneous bandwidths of 2 GHz at an 18 GHz center frequency. The steering system shall be capable of steering from -20o to +60o in the elevation plane and from -45o to +45o in the azimuth plane without the development of real space grating lobes. The main beam of the antenna system shall be a 2o x 5o pencil beam.

**PHASE I:** The goal during Phase I is to create a producible design for the above described antenna. This effort will include computer modeling to predict the antenna's expected performance.

**PHASE II:** Phase II will have two goals. The first goal will be to fabricate the antenna designed in Phase I. The second goal will be to test the antenna on a Government antenna range.

**PHASE III DUAL-USE APPLICATIONS:** This technology has potential commercial and military use for all applications involving non-mechanically steerable antennas. From a military perspective, the applications for this technology in air defense radars and wide bandwidth communications systems would be quite broad. In the commercial world, FAA air traffic control radars and commercial weather radars are just two of many areas in which this technology could be applied.

**OPERATING AND SUPPORT COST (OSCR) REDUCTION:** A MEMS based array antenna offers several operating and support cost reduction opportunities. The devices currently used in electronically controlled array antennas are a cost driving item. Current projections indicate the MEMS devices that will replace them will be significantly less expensive, thereby, reducing both purchase and repair costs. In addition, MEMS based array antennas will be lighter in weight than their electronic counterparts. This will result in both lower transportation costs per unit as well as increasing the number of units that can be transported per transport. Also, MEMS based systems typically require less prime power than their electronic counterparts which will reduce their basic operating cost.

**REFERENCES:** N. S. Barker and G. M. Rebeiz, "Distributed MEMS True-Time Delay Phase Shifters and Wideband Switches", IEEE Transactions on Microwave Theory and Techniques, April 1998.

**KEYWORDS:** MEMS switches, array antennas, radar, beam steering, wide bandwidth

A99-155      **TITLE:** An Effective Mixing Process for Gelled Propellants

**TECHNOLOGY AREAS:** Weapons

**OBJECTIVE:** Develop an innovative, variable-volume, closed-batch process for making gelled propellants. Liquids that are toxic, corrosive, and volatile are to be gelled with sub-micron particulates that may have a very low bulk-density and/or may be chemically reactive with the liquids. This novel process will include the design, fabrication, and demonstration of lab-scale, prototype mixing hardware. The process design should also be able to scale-up directly for future manufacturing. Batches will meet or exceed current Army propellant gel specifications.

**DESCRIPTION:** An innovative process will be developed to disperse homogeneously sub-micron solids within liquids that are toxic, corrosive, and volatile. The process must comply with all of the following mixing requirements: - any ingredient additions throughout the process must not allow exposure to the environment - the system must fully retain any volatile fuel or oxidizer components but allow pressure-relief of any reaction gases - the process must be able to handle effectively batch volumes from two to eight liters - the process and mixing vessel must accommodate solids with very low bulk densities, i.e. fumed silica - the process must not retain any kind of gas within the completed gel, including air or purge gases, reaction gases, or vaporized volatiles - the process must wet all solids and complete any gassing before gelation viscosities preclude escape of the bubbles - the mixing system must control batch temperatures between -40 and +60 EC with "1EC precision - the completed gel must be able to expel directly into an attachable receiving tank (the completed batch must not be exposed to the environment) - all processes must be suitable for volatile flammable liquids.

**PHASE I:** Perform processing and system analyses to determine the most effective approach for this innovative mixing process. Design the prototype system, identified in the analyses, that complies with all of the process and mixing specifications.

**PHASE II:** Fabricate, demonstrate, and deliver two prototype gel processing systems, for fuels and oxidizers, that will meet laboratory installation and operational specifications. Verify the functionality of the systems and their ability to make batches that will comply with all of the Army gel characterization specifications.

**PHASE III DUAL-USE APPLICATIONS:** Improvements in mixing technology and industrial processes are directly applicable to any commercial operation that blends or disperses solids into liquids. Some examples might be: Clorox® Gel,

pharmaceutical processing, cosmetics, gelled toothpaste, etc. The closed-batch, environmentally safe approach required by AMCOM could also apply to various areas of sanitary processing or commercial processes involving toxic materials.

**OPERATING AND SUPPORT COST (OSCR) REDUCTION:** Direct savings would be recognized by reducing the number of out-of-spec gel batches for R&D testing, by reducing the processing time, and by increasing the safety of operators, facilities, and the environment. Gelled bipropellants have lower cradle-to-grave costs than traditional solid propellants. The development of an effective process to gel fuels and oxidizers will accelerate R&D capabilities in gelled bipropulsion. This will indirectly enhance the development of a single advanced missile that could replace several single-use systems currently deployed. Such a system would greatly reduce logistics and training costs. The variability and precision of bipropulsion thrust control increase kill probability and multi-mission flexibility, thereby reducing the number of missiles needed in the arsenal. The savings to the government could exceed \$1B if a single missile replaces several existing systems. If multiple systems are to be retained, common hardware could be horizontally integrated into TOW, Dragon, Hellfire, and possibly Stinger missile systems.

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1. Higashitani, K. In Powder Technology Handbook; Gotoh, K. et al., eds., 2nd ed., Marcel Dekker: New York, 1997; pp. 475-484.
2. McDonough, R. J. Mixing for the Process Industries; Van Nostrand Reinhold: New York, 1992; pp. 135-137.
3. Schramm, L. L., ed. Suspensions: Fundamentals and Applications in the Petroleum Industry, Advances in Chemistry Series 251; American Chemical Society: Washington D.C., 1996.
4. Perry, R. H. and D. W. Green, eds. Perry's Chemical Engineers' Handbook, 7th ed.; McGraw-Hill: New York, 1997.
- Shamlou, P. A. Processing of Solid-Liquid Suspensions; Butterworth-Heinemann: Boston, 1993.

**KEYWORDS:** mixers, dispersing equipment, particle dispersion, deflocculation, colloidal suspension, gel propellant,

A99-156      TITLE: Application of Spatial Antenna Arrays/Processing for Command, Control, and Communications with Unmanned Ground Vehicles (UGV)

**TECHNOLOGY AREAS:** Information Systems Technology

**OBJECTIVE:** To demonstrate a capability to achieve high quality command /communications and imagery transmission with an RF data link during a non-line-of-sight scenario at ranges of up to 10 kilometers in a Unmanned Ground Vehicle (UGV) application (i.e.: ground to ground communications without relay or elevated antennas).

**DESCRIPTION:** The control of UGVs and UAVs is often compounded by the problem of multiple signal reception caused by multipath and signal diffraction. For UGVs this problem limits the effective range for which a UGV can be controlled. For a UAV this problem creates a safety risk in situations where the landing site is in close proximity to terrain structures (i.e. on a ship or in a field site where trees are close). A partial solution is to use multiple antennas on the vehicle, which by means of proper wavelength spacing can overcome this situation. However, this creates the reception of multiple signals, which can be both interfering as well as constructive. This creates increased noise problems and increased errors in data decoding. The purpose of this SBIR is to develop and apply signal processing algorithms and antenna arrays using the techniques of spatial antenna arrays to allow the objective control of a UGV. Current commercial efforts for cellular telephony, vehicular communications, and satellite communications are examining the problem of multiple signal reception and addressed hardware and software techniques to overcome the signal errors associated with such. These 'spatial array' or 'spatial processing' techniques are addressed chiefly for the area of narrow bandwidth signals (typically 3 kHz bandwidth), which are directly applicable to the UGV/UAV command/control problem. These processes have not been addressed for wide bandwidth imagery signals, which constitute a critical element for the UGV and UAV applications due to the need for remote driving or landing and takeoff.

**PHASE I:** Phase I will consist of identification of spatial processing algorithms and antenna arrays for use in the UGV application. A search of algorithms would be compiled and examined for application to the wideband imagery transmission. For UGV application, the wideband imagery requirement is for dual stream (i.e. stereo vision), real-time video to accomplish driving of the UGV. Differentiation for digital transmission processes shall be based on frequency selection, error reduction, timeliness of throughput, and adaptability as a minimum set of critical factors. An algorithm will be selected as a best approach candidate for each solution, and a study performed to estimate the performance in terms of signal error rates, projected range, and antenna array spacing. Frequency considerations should be examined based on typical UGV data links (L, S, or C bands). The results of the analysis will be used to design a system to demonstrate the effectiveness of the candidate algorithms and arrays.

PHASE II: Phase II will consist of development and demonstration of the spatial processing algorithm and antenna array selected in a real world scenario. This phase will consist of algorithm coding and building of RF hardware to model and demonstrate the algorithm's/array's effectiveness in reduction of transmission errors occurring in the transmission path, and to demonstrate improved range performance. The system developed would be evaluated for the improvement of both signal transmission and reception. The system developed should be capable of operating on a computer operating with a Windows 95 or NT operating system. Demonstration of any resultant hardware system can be arranged at Redstone Arsenal, AL on test ranges utilized for development of UGV systems. Delivery of the model shall be made to AMSAM-RD-MG-IP at Redstone Arsenal for evaluation.

PHASE III DUAL-USE APPLICATIONS: The signals transmitted for a UGV or UAV application are of two types, the first being command and status telemetry, and the second being sensor imagery. The application of the spatial array processing technology to non-military use exists in several commercial markets. These include the cellular telephone and digital broadcast (television) markets, as well as the robotic vehicles market (typically for police surveillance but also for heavy industry (transportation, energy). The application of the spatial array techniques developed under this effort will assist in providing transmission with reduced signal losses and signal noise in urban or high clutter environments where these markets are predominant. These applications include the use of point to point direct communication or network relayed communications.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The chief benefit in cost reduction by the use of this technology, for UGV applications, is in the elimination of the need for fiber optic communications for ground vehicles. The use of RF transmission for extended range (up to 10 km) for UGVs eliminates the weight, volume, and storage requirements for the fiber. Further the vulnerability and restrictions of fiber to vehicle movement are eliminated. The cost benefit for UAV type applications is the improved signals during critical flight functions (landing and takeoff) which reduce the risk of flight, and therefore of loss of hardware.

KEYWORDS: Antenna arrays, wideband coherence, spatial error correction algorithms, multiple signal reception.

REFERENCES: V. M. DaSilva and E. S. Sousa, "Fading-Resistant Modulation Using Several Transmitter Antennas", IEEE Transactions on Communications, Vol. 45, October 1997. Proceedings of the 47th Annual Vehicular Technology Conference, IEEE.

## **Natick Soldier Center (NSC)**

A99-157 TITLE: Onsite Packaging and Food Waste Disposal (Safe Incineration)

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To demonstrate the ability to reduce packaging and food waste to nonhazardous byproducts through combustion.

DESCRIPTION: Field feeding produces tons of packaging and food wastes that must be back hauled to landfills at great expense. An onsite packaging and food waste disposal method is needed that unequivocally reduces waste to nonhazardous byproducts to reduce or eliminate this enormous logistic burden. Municipal and light industrial incineration/treatment technology shows the promise of processing wastes with a variety of approaches that are intended to meet EPA clean air standards. However, municipal wastes can include a wide range of products, and industrial wastes can include very dangerous chemicals. In addition, municipal and light industrial applications are stationary with relatively large amounts of electric power available for processing. Field feeding waste reduction is a simpler problem because it only includes a narrow spectrum of plastic, paper, and food products. However, the equipment must be robust, portable, and of minimum power. A prototype shall be designed to fit within a pallet envelope, that is capable of reducing battalion level wastes (63 cubic feet) to non hazardous products. The waste disposal system may operate with diesel fuel, but it is desired that the system use little or no electric power.

PHASE I: Establish the basic operating concept through the design and development of a proof-of-principle prototype, demonstrate operation and reliability, and provide strategies to meet all described requirements with minimal risk. Address EPA clean air act, safety, and human factors.

PHASE II: Refine the design to meet all requirements and fabricate 2 prototypes for technical and operational tests. Address manufacturability issues related to full-scale production for military and commercial utilization

PHASE III DUAL USE APPLICATIONS: This basic waste disposal technology targeted for food and packaging waste has application for outdoor events such as fairs, carnivals, and camps, as well as indoor food service such as lunch rooms, cafeterias, and all types of institutional or consolidated food service, both commercial and military.

REFERENCES: Army Food Service Operations Manual: FM 10-23, Marine Food Service Doctrine, Navy Galley Sanitation Doctrine

OPERATING AND SUPPORT COST (OSCR) REDUCTION: This topic supports Operational and Support Cost Reduction (OSCR). In addition to the cost and effort required to transport wastes, and the fees associated with municipal incinerators and landfills, there are other less quantifiable but equally important benefits to onsite disposal. Wastes can be disposed of as they are produced eliminating the mountainous piles of hazardous garbage that accumulate. These wastes are an eyesore and can blow around the site during mission exercises. The garbage piles attract vermin that can exacerbate health hazards. An onsite incinerator that produces only water vapor and carbon dioxide will have global acceptance. This global acceptance will eliminate the negotiation process that occurs whenever an "outside" military force requests disposal of wastes at local facilities, subject to local discretion, and local interpretation of environmental impact and associated fees.

KEYWORDS: waste, disposal, incineration, food, packaging

A99-158 TITLE: Portable Rapid Analytical Technology for Food Safety

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Exploit biosensor technology to provide military food inspectors with a rapid, simple, objective early detection system of microbial safety for military feeding scenarios.

DESCRIPTION: Biosensors are a special class of sensors that associate a biological component with some type of transducer to provide a mechanism for detecting changes in the biological/chemical component. Recent breakthroughs in molecular recognition, fiber optics, sensitive luminescent reagents and instruments make this a particularly promising technology to apply to food systems. The concept consist of molecular recognition compounds of biological origin (enzymes, antibodies, etc.) immobilized on a platform, and the interaction between the recognition compound and substrate is monitored by their attenuation of electrical, magnetic, optical signals, etc. This effort will lead to the fabrication of a lightweight packaged portable prototype biosensor. The device will result in fast detection of potential safety risk from pathogenic bacteria in fresh, prepared or exposed foods that are brought with the troops or obtained through host nation procurement. FDA scientists have indicated that up to 2 percent of all fresh produce, both foreign and domestic, are contaminated with disease causing organism, some discovered only in the last few years. Benefits envisioned include improvements in logistical handling of rations, improved health and performance of the soldier by preventing potential food borne type illnesses and increased rations quality/acceptability.

PHASE I: Identify a biosensor technology suitable for the detection of one of the following pathogens: *Campylobacter jejuni*, *salmonella* spp, *E coli* O157:H7 or *Lysteria monocytogeneis*. Investigate miniaturization of instrumental detection systems for design of a portable biosensor system that would sensitively detect the selected pathogen. Demonstrate potential application of this technology to food systems with emphasis placed on the need to accurately identify the pathogen from a complex mixture of interferents/competing pathogens.

PHASE II: Incorporate any design refinements indicated in Phase I to include improvements in instrument sensitivity, and develop a prototype packaged unit for field test applications selected from the biosensor system of Phase I. Prototype design should include probe/platform development for one microbiological pathogen. Demonstrate prototype in selected ration systems.

PHASE III DUAL USE APPLICATIONS: Biosensors have a wide potential application in the food industry, environmental testing, industrial processing and the military. The proposed instrument can further be adapted to the detection of any food pathogen. Recent outbreaks of food borne illnesses and disposal of potentially contaminated foods demonstrate the need for this technology and its application to the commercial food industry.

OPERATORING AND SUPPORT COST (OSCR) REDUCTION: This topic supports Operational and Support Cost Reduction (OSCR). Portable biosensors will not only ensure the safety of the military food supply but also will allow food inspectors to make rapid, objective decisions regarding the quality of prepositioned military rations for logistic distribution. This technology will allow the real-time determination of typical food deterioration processes, from early to late stages of the process, that will result in virtual decisions regarding the logistical handling of ration items. Rations will then be supplied based on actual quality and not on predetermined shelf life requirements. This will reduce logistical waste from military TISAs, as well as, reduce the cost in labor for removing uneaten rations (waste) from the field.

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KEYWORDS: Biosensor, rapid microbial test, portable instrumentation, immunosensor, food pathogens

A99-159 TITLE: High-speed/Low-cost Impermeable Seaming for Synthetic Tentage and Collective Protection Shelters

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To explore methods of seaming synthetic fabrics to produce a water and vapor proof seam suitable for high speed manufacturing of tents and collective protection structures. This will reduce the fabrication cost and increase the quality of finished tentage and Chemical/Biological resistant soft shelters that require water and or vapor proof seams.

DESCRIPTION: Military and commercial clothing, equipment and soft shelters are currently fabricated using a number of techniques, the most common of which are sewing or some type of heat sealing such as thermal, ultrasonic or Radio Frequency (RF). In some cases a combination of methods are used. Each of these techniques has both desirable and undesirable qualities. Sewing operates at high production rates, can be easily stopped and started during the seaming operation and can be visually inspected to insure a quality seam has been formed. The drawback to sewing synthetic fabric is that the hot needle creates a stitch hole that becomes a leakage point for water or vapor. Heat sealing creates a water and vapor proof seam but is substantially slower and less forgiving to starting and stopping during the seaming process. It also requires destructive testing of random end items or coupons that are created during the manufacturing process to insure a quality seam. The combination of sewing and thermal tape sealing seams eliminates some of the problems but doubles the manufacturing process since the sewn seam which is created at relatively high speeds must then be processed through a hot taping machine that operates at speeds slower than a sewing machine. One potential technology to be explored is a composite sewing thread that expands after sewing (possibly by application of heat) to fill and seal needle holes. Laser technology may also have potential as a means of creating the energy required to weld synthetic fabrics together. The application for a high speed, low cost method of seaming synthetic fabrics is extensive. Water and vapor proof seams are required for tents, tarps, truck covers, convertible car tops, shoes, boots, gloves, Chemical Biological (CB) resistant garments and shelters, packs, pouches and equipment in general as well as many other applications.

PHASE I: Determine minimum strength requirements and water and vapor resistance required for a sampling of end items. Suggest innovative methods for reducing the cost and speeding the processes associated with creating structural water/vapor proof seams. Determine the feasibility of each method and a trade-off analysis discussing all performance parameters including production rates, hydrostatic resistance, physical properties and costs. Demonstrate the effectiveness of methods by creating seams from a minimum of five different synthetic fabrics.

PHASE II: Refine the most promising concept(s) discovered in Phase I. Fabricate full-scale prototypes of several types of end items and perform performance, manufacturability and durability testing to determine overall performance.

PHASE III DUAL USE APPLICATIONS: The US imports and internally manufactures a wide range of military and commercial products that require water/vapor proof seams. These include shoes, gloves, Hazardous Material (HazMat) suits, tents, equipment, truck covers, tarps, CB resistant shelter and clothing, pond liners, dump liners, marine products and many others.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: High speed, low cost manufacturing techniques and or equipment will reduce the initial purchase cost of tentage, equipment and collective protection equipment. Studies have shown that 20 to 30 percent of the labor involved with producing water proof or CB resistant tentage involves the seaming process. Defense Logistics Agency (DLA) bought more than 110 million dollars worth of water proof clothing and tentage in FY98. Water proofing General Purpose (GP) Medium tents after the initial deployment into Bosnia cost several million dollars in terms of providing and implementing field fixes. Reduced morale and quality of life from living in tents that leaked at the seams was an issue that reached the highest levels of the Pentagon. It is important to make synthetic fabrics work on current tentage as it is an improvement in terms of the reducing the burden of having to retreat old cotton tents with environmentally hazardous chemicals.

KEYWORDS: Seam, sewing, sealing, impermeable, clothing, tentage, chemical, biological

A99-160

TITLE: Human Performance Modeling of Paratrooper Landings

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Improve and apply currently available biomechanical models (e.g. JACK, ADAM, SIMM, etc.) to simulate the landing motion of a parachutist, to analyze the impact forces on the parachutist, and to develop new concepts for minimizing landing injuries.

DESCRIPTION: Statistics from the US Army Safety Center<sup>1</sup> show that the leading cause of tactical parachuting injuries is improper parachute landing fall. Currently there is a lack of understanding of the various independent factors, such as total weight, landing velocity, body position, etc., that affect the impact forces on the lower limb, and cause ankle/knee injuries. 2-6 A proper biomechanical analysis and model of landing impact along with physiological data are needed to understand this critical process during personnel airdrop, to provide guidance on new protection design and methods, and ultimately to decrease body injuries. Two SBIRs on human dynamics modeling of walking motion are currently being supported by the U. S. Army Research Office (ARO).

PHASE I: This phase will concentrate on obtaining available physical properties of the human foot, leg, trunk, ankle joint, knee joint, and hip joint as related to analysis. A biomechanical model of the human body will be developed based on currently available models. This model will then be used to investigate the impact forces on the body as a function of landing velocity, total weight, and body position prior to impact. Based on the analytical results, guidelines for proper landing fall and new concepts for minimizing landing injuries will be developed.

PHASE II: This phase will be an experimental investigation of the landing dynamics to provide a database to check the adequacy of the computer model developed in Phase I. The computer model will be further refined to accurately predict the impact forces on the body. Proper landing fall and technique will be developed. New concepts will be developed and tested in a laboratory to show their benefits and protection.

PHASE III DUAL USE APPLICATIONS: The computer model, the generated guidelines and the protection system will be very useful for training and combat of the airborne soldiers, and design of advanced parachute systems, such as the Advanced Tactical Parachute System (ATPS), for safe personnel landing. Through proper training and external support methods, the current leading injuries caused by improper landing fall will be greatly reduced. These applications and benefits should be able to extend to the commercial market in recreational sport jumping using ram-air canopies or hang-gliders, foot injuries in sports (gymnastics, track and field, hiking, etc.), and smoke jumpers for fire fighting.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Ankle injuries account for 30%-60% of military jump-related injuries. It is anticipated that proper landing fall and effective limb support systems will significantly reduce ankle injuries. A cost benefit analysis performed by the U.S. Army Research Institute of Environmental Medicine, Natick, MA<sup>8</sup> has shown that a 50% reduction in ankle injuries during parachute landing would result in more than 2 million dollars in savings per year.

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KEYWORDS: Biochemical modeling, jumper landing impact, impact modeling parachute safety

**U.S. Army Space and Missile Defense Command (SMDC)**

A99-161      TITLE: Fluorine and other Extremely Hazardous Chemicals Gas-handling Equipment

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To create an advanced innovative fluorine and/or other extremely hazardous chemical gas handling equipment for use with military HF/DF chemical lasers and/or other industrial hazardous chemical handling applications.

DESCRIPTION: We at the High Energy Laser Systems Test Facility (HELSTF) operate very high power HF/DF chemical lasers for the U.S. Army. These laser operations involve the combustion of many pounds of extremely reactive and toxic gaseous Fluorine and Nitrogen Trifluoride. Fluorine gas handling is one of the primary safety concerns at the HELSTF. The focus for this topic is innovative new approaches to Fluorine gas handling. Current Fluorine gas handling is accomplished using K-bottle, material, and valve designs dating from the uses of chlorine early in this century. Specific possible innovations include the optimization of materials (material cost and machining costs vs. compatibility with Fluorine), valve designs, coupling designs, regulator designs, pipe fitting designs, fluorine pump designs, storage container designs, high sensitivity sensors, electrolysis systems designs and innovative designs for trapping systems that are made to consume excess fluorine. Fundamental chemical, material science, and engineering understanding of issues such as reliability, safety, mean time between failure, ease of use, ppm to ppb exposure levels, and risk management are the explicit keys to success in this topic area.

PHASE I: Proposers should plan on early experimentation to demonstrate proof of principle for their innovative ideas. A detailed effort to further identify the usefulness of the proposed equipment for the broader classes of high power lasers and for uses in similarly dangerous hardware applications in military/commercial/industrial settings will be required. Detailed design for a Phase II hardware product demonstrations is also required. The ability to attract Phase III commercial partners for funding is highly regarded.

PHASE II: Second Phase efforts will include hardware fabrication, and demonstration at HELSTF using the Army LDD and MIRACL lasers. Army contractor personnel will be necessarily involved in any actual modifications to fluorine systems. Publication of results at all phases is encouraged to attract follow-on interest. Success in Phase II may lead to a follow-on effort completely upgrading the MIRACL (Megawatt class) laser fluorine gas handling sub-systems.

POTENTIAL COMMERCIAL MARKET: The market for advanced hazardous gas handling equipment may be very large because it could lead to the creation of new industrial applications for chemicals now rightly viewed as too dangerous to routinely handle. By inventing and developing new hazardous chemical equipment/components new material synthesis can be opened up therefore leading to an industrial demand for the equipment itself.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Improved hazardous gas handling will lower operating and support costs. Improvements will improve safety, lower storage costs and make operations more reliable.

REFERENCES:

1. "Fluorine Systems Handbook, Section VI, Dynamic Compatibility of Fluorine with Metals", R.E. Anderson, AFRPL-TR-72-119, October, 1972.
2. "Handling and Use of Fluorine and Fluorine-Oxygen Mixtures in Rocket Systems", H. Schmidt, NASA SP-3037, 1967.

KEYWORDS: chemical handling equipment, fluorine compatible materials, advanced fluorine gas handling, HF/DF chemical lasers

**U.S. Army Simulation, Training, and Instrumentation Command (STRICOM)**

A99-162      TITLE: Robust, Low-cost Target System Data Link

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Develop and demonstrate a low cost target system data link using an innovative implementation of commercial technology to transmit data between target control stations and ground and air targets. The system may apply emerging commercial telecommunications data link capabilities to allow the elimination of unique, dedicated target control systems for existing and future targets.



**DESCRIPTION:** Current and projected military target systems employ a control station to allow control inputs from operators and receive data from targets, a dedicated data link, and a transceiver in the target to receive control inputs and transmit data. Current target systems employ relatively low data rates of approximately four Kilobits/second. Continuous connectivity between the target and the control station is essential to insure safe operation of the target. Range configurations and training/test scenarios often require operation of targets when direct line of sight between the target and the operator are not possible. Technical advances like the low earth orbit satellite based commercial telecommunications are beginning to provide reliable worldwide linkages between users. While each system uses different telecommunications techniques, all are focused on reliable, high volume, and low cost applications. The goal of this research will be to develop a capability to provide a continuous data link between a target control station and a maneuvering target vehicle. If sufficient reliability can be demonstrated using a commercial telecommunications data link for target system control, the dedicated data link could be eliminated from current and future target systems.

**PHASE I:** Analyze a sample of existing target-control station data link requirements and develop a method to provide a continuous, economical data link which is not impeded by data transmission latency or transmission routing shifts inherent in commercial telecommunications networks.

**PHASE II:** Build a prototype of the target control data link system established in the Phase I effort and demonstrate its capability to provide continuous control of a target using commercial telecommunications circuits. The demonstration area, target, and personnel to support target operation will be provided by the Government to support the prototype demonstration. The effort will provide a detailed analysis of the demonstrated technical capabilities of the prototype and its ability to meet this operational requirement.

**PHASE III DUAL USE APPLICATIONS:** This technology implementation could have impact for commercial area security systems, and has potential for operations in natural disaster team support. If telecommunication networks, demonstrating the more complex functions required to control a maneuvering target system over telephone circuits could facilitate the investigation of more complex, positive control, applications of these communication networks. **OPERATING AND SUPPORT COST REDUCTION (OSCR):** If this research can be effectively used to provide target control data link connectivity, military unique receivers and transmitters currently in use could be replaced with commercial equipment reducing the organic maintenance and spare part cost associated with these items.

**REFERENCES:** Additional information on the Targets Management Office (TMO) and some of the target systems they employ can be found at the Project Manager for Instrumentation, Targets & Threat Simulators world wide web page at "<http://www.stricom.army.mil/STRICOM/PMITTS>".

**KEYWORDS:** telecommunications systems, low earth orbit satellite communications system, data link system, positive control network system

A99-163                      **TITLE:** Software Tools for Visualization of Terrain Databases

**TECHNOLOGY AREAS:** Information Systems Technology

**OBJECTIVE:** To develop and demonstrate tools, processes, and standards for rapid prototyping, dissemination, and collaborative visualization of terrain databases.

**DESCRIPTION:** Disparate applications of modeling and simulation frequently require that teams of individuals, separated by long distances, collaboratively visualize terrain databases. Generally, these individuals will have different computer platforms, a range of download capabilities, and different display and navigation devices. These disparities can make it very difficult for each viewer to exchange meaningful information about the terrain. This topic addresses processes and software tools for collaborative visualization of terrain databases. Target applications for this development include as a minimum: 1) subject matter experts, at diverse locations, collaborating in the development of a geospecific terrain database for simulation, 2) members of a task force responsible for collaborative mission planning, 3) collaborative mission rehearsal, and 4) distance learning.

**PHASE I:** Develop and demonstrate a process and prototype tool set for converting terrain databases in the Synthetic Environment Data Representation & Interchange Specification (SEDRI) standard transmittal format for dissemination over the Internet. This process and tool set shall address key issues of collaborative visualization: compression (with no loss or minimal loss of information) to reduce download times and storage, enforcement of similar appearance on diverse platforms, and scalability of content.

PHASE II: Develop software that automates the process of planning, formatting, and compressing terrain databases for collaborative, Internet-based viewing. Develop downloadable navigation aids that allow multiple viewers to accurately identify points of interest, paths, etc.

PHASE III DUAL USE APPLICATIONS: Internet gaming, distance learning for K-12 and university students as well life-long learners, and emergency management.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Terrain Database development for M&S applications currently costs from \$1M to \$5M depending on the complexity of the simulation and size of the terrain database. Software tools to support database development and evaluation could significantly reduce database development costs.

REFERENCES: [www.sedris.org](http://www.sedris.org)

KEYWORDS: terrain databases, simulation, SEDRIS, software tools

A99-164 TITLE: Multi-resolution Modeling

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop the technology for using one simulation model set in multiple applications. One option is to maintain a consistent set of interface objects (i.e., entity location and state) that are fed by one branch of an underlying model set tree. The underlying models would consist of two or more models with different resolutions (i.e., an platform level movement model and an aggregated movement model with a set of formation templates). The active model being used during simulation execution could be switched within the model set without requiring additional software to be loaded or the exercise to be paused.

DESCRIPTION: The Advanced Concepts and Requirements (ACR) will use OneSAF for analysis, the Research, Development and Acquisition (RDA), and the Training, Exercises and Military Operations (TEMO) for battalion and below training and mission rehearsal. Even though these uses have somewhat different requirements (i.e., real time vs fast as possible, after action review vs data analysis, Y), the Army's desire is to use the same model set to support these different uses. The Army currently has many different models and simulations, each with their own specific purpose. The simulations operate on different platforms, with different operating systems and different simulation infrastructures. The Army's desire is to develop future models and simulations that will be usable for many different applications. For example, the Warfighter's Simulation 2000 (WARSIM 2000) is currently under development as a replacement for the Corps Battle Simulation (CBS), the Tactical Simulation (TACSIM) and the Combat Service Support Training Simulation System (CSSTSS). The primary use for WARSIM 2000 will be to train the commanders and staffs of battalion through echelon above corps units. In this role, WARSIM will provide a detailed simulation of the combat activities with less detail in the combat service support representation. However, in its role as the driver for Combat Service Support training, the WARSIM system will need to switch its processing focus to more detailed modeling of the logistical representation and less detail in the representation of combat activities. Similarly, WARSIM will need to support an intelligence-focused exercise as the replacement for TACSIM. The Army's desire is to use one model set that supports all of these applications.

PHASE I: The Phase I effort should focus on investigation of current research efforts of methodologies for developing multi-resolution models and an analysis of which are appropriate for Army simulation systems. The product of the Phase I effort should be a technical report.

PHASE II: The Phase II effort focus on development of a prototype model using the results from Phase I. The products of the phase II effort should include; a report describing the contractor's choice of an area to model, a conceptual model of the area chosen, object oriented software models (both static and dynamic models from an established object oriented methodology of the contractor's choice), and an operating implementation of the model set. The implementation model can be demonstrated in either a contractor provided testbed or a freely available simulation framework (such as OSim or SPEEDES).

PHASE III DUAL USE APPLICATIONS: Successful completion of this effort will put the offering contractor in an position to either develop or participate in the development of commercial simulation systems. Potential commercial application areas include video games (i.e, PC games, TV based game systems, etc.), virtual reality rides, and non-military training systems (such as truck driver trainers).

OPERATING AND SUPPORT COST (OSCR) REDUCTION: Successful development of multi-resolution models would reduce the Army's overall simulation operating costs by; reducing the software that needs to be developed (and supported), reducing the number of hardware platforms that need to be supported, and increasing the application areas for simulation systems under development.

#### REFERENCES:

Text book: Gamma, Erich, Richard Helm, Ralph Johnson, John Vlissides. Design Patterns - Elements of Reusable Software. Addison-Wesley, Reading, MA, 1995. (ISBN #:0-201-63361-2)  
World Wide Web sites: US Army Simulation Training & Instrumentation Command (<http://www.stricom.army.mil>)  
WARSIM (<http://www.stricom.army.mil/PRODUCTS/WARSIM/>)  
US Army National Simulation Center WARSIM Directorate - (<http://www-leav.army.mil/nsc/warsim/index.htm>)  
OneSAF - (<http://www-leav.army.mil/nsc/stow/saf/onesaf/index.htm>)

**KEYWORDS:** multi-resolution modeling, simulation systems, conceptual modeling, object oriented software development

#### **U.S. Army Tank, Automotive, and Armament Research Development and Engineering Center (TARDEC)**

A99-165      **TITLE:** Unique Hardkill Active Protection Countermeasures Mechanisms

**TECHNOLOGY AREAS:** Ground and Sea Vehicles

**OBJECTIVE:** In support of our future Defense Technology Objective (DTO) and Science Technology Objective (STO) efforts, the objective this SBIR is innovative research to devise, develop and test/demo close-in sense and detection concepts/technology for use in triggering active protection (AP) defeat mechanism countermeasures (CM) that can physically disrupt and defeat large caliber anti-tank threats while they are in flight. This effort shall investigate close-in detection electronics, with adaptive response methods, that will trigger an AP countermeasure to defeat the threat projectile. This combined close-in AP-Sensor/CM system should be potentially effective against all classes of large caliber threats, including large caliber kinetic energy threat projectiles. This sensor/CM system should use technologies that can be eventually miniaturized and packaged into a small deliverable size. Such an advanced AP-Sensor/CM system is desired for use in improving vehicle survivability.

**DESCRIPTION:** Currently AP systems concepts/designs use command or time detonated blast effects, fragments and high velocity/mass impact methods and mechanisms without the use of a close-in final triggering sensor. None of these approaches are very unique, innovative or very "high-tech". This SBIR effort shall research, development and use advanced electronic methods to detect the close-in presence of threat objects and help to focus and direct the defeat mechanism. New innovative concepts and methods for selecting and triggering the proper response mechanism shall be investigated. This combined sensor/CM response mechanism would be useful for respond against the full range of different threat objects since it would be "smart" enough to respond differently and appropriately. Selected parts of this "smart" device will have applications to a very wide range of applications requiring quick detection and response electronics.

**PHASE I:** The contractor shall research advanced technologies and components required for low cost close-in sensing of threat projectiles to trigger the quick directed response defeat mechanism needed to defeat the threat. The contractor shall identify and verify the technologies available for use can eventually be miniaturized and packaged in to a small deliverable package, ideally about 4" in diameter and 6" long, and have a detection range of several meters. The contractor shall devise and design the concept development program outline. The contractor shall also identify and devise their concept for use in commercial applications.

**PHASE II:** The contractor shall design, assemble and test concept field testing hardware. The contractor shall test/demo their concept system against select threat devices. The contractor shall develop advanced development plans for their system. The contractor shall develop a plan for the commercial use and applications of selected and appropriate parts of the concept.

**PHASE III DUAL USE APPLICATIONS:** The advanced electronics and concepts that will be used for this effort will have direct applications for various police forces, airport security applications, bank facilities security. This will have applications in many military and non-military vehicles in future collision avoidance and convoying systems. The sensing and electronics components of this effort will/should have direct applications to security force applications in the form of weapons detection devices of one form or another. Even home and parking lot security systems could apply the advance electronics devices that would be used in this effort.

**OPERATING AND SUPPORT COST REDUCTION (OSCR):** The Army has thousands of combat vehicles and facilities on which these technologies will support and provide improved survivability and security. This effort will support the advancement of facility security equipment through out Army and anywhere else needing protection. The basic design and development will not have to be repeated every time, resulting in cost savings.

**KEYWORDS:** vehicle survivability, countermeasures, close-in sensing

## **U.S. Army Topographic Engineering Center (TEC)**

A99-166      TITLE: Methods for Achieving Improved Position and Orientation Performance from Small, Low-cost Sensors

TECHNOLOGY AREAS: Ground and Sea Vehicles; Sensors, Electronics, and Battlespace Environment

OBJECTIVE: The objective is to identify emerging, small, low-cost Position/Navigation (POS/NAV) hardware whose individual performances yield moderately accurate position and orientation data but when integrated together into a system yield highly accurate information. Once the POS/NAV sensors are identified, algorithms and hardware arrangements are developed and tested.

DESCRIPTION: Today high accuracy for position and orientation determining systems equates to high cost, large size and heavy weight. New sensors with application to POS/NAV are emerging from advanced solid-state technology and from micro-electro-mechanical system (MEMS) technology. These sensors are small, lightweight and low-cost. Advancements are also being made in the techniques for integrating several stand-alone POS/NAV systems together to form robust, full time, accurate POS/NAV systems. This effort would identify currently available solid-state and MEMS sensors, which are at the stage where integration offers the potential for improved POS/NAV performance. Using the identified characteristics of these sensors, a concept integration algorithm would be developed. Using modeling and simulation, the interaction of sensors, the type of sensors, and the integration algorithm would be used to establish the potential performance goal. The potential for a single system or the need for a family of systems which meet the Army POS/NAV requirements would also be determined. A system or a family of systems would be developed, tested and shown to potential users.

PHASE I: Identify emerging sensors which support determining position and orientation and lists their strengths and weaknesses when used to determine position and orientation. Select those sensors whose integration offers the potential for improved accuracy in determining position and orientation. Develop a proof-of-concept integration algorithm and demonstrate by modeling and simulation techniques the potential for improved performance. Establish the need for a single system or need for a family of systems to meet the Army' POS/NAV requirements.

PHASE II: Develop a hardware design for the integration of the sensors identified in Phase I. If it is determined in Phase I that a single system can not be developed, a family of systems will be developed. Improve the algorithm developed in Phase I and test with the hardware. Demonstrate by operating the system in non-integrated mode and in integrated mode that the system or systems work with high accuracy on platform or platforms for which it was designed.

PHASE III DUAL-USE APPLICATIONS: The system would have utility by the civil side of government and the commercial community. The system would be an affordable accurate navigator which would support manned or unmanned hazardous waste clean-up vehicles, navigation for the general public, navigation and location for the transportation industry and many other uses.

OPERATING AND SUPPORT COST (OSCR) REDUCTION: The reduced cost of the system, parts and potential ease of maintenance contribute to OSCR. Adding a navigation capability to Army resupply and support vehicles may reduce the transportation time and the associated man-hours. If the location of resupply and maintenance vehicles is known, redirection is possible and allows the efficient redirection of supplies, spare parts and maintainers to critical locations.

REFERENCES: (1) Future Operational Requirements for TRADOC and Battle Labs (2) Future Positioning and Navigation Technologies Study, Prof. Klaus-Peter Schwarz and Dr. Naser El-Sheimy, University of Calgary, to be published

KEYWORDS: positioning, navigation, orientation, sensors, low cost, integrated

## **U.S. Army Test and Evaluation Command (TECOM)**

A99-167      TITLE: Marrying Commercial-off-the-shelf (COTS) and Government-off-the-shelf (GOTS) Equipment for Tracking Chemical Releases

TECHNOLOGY AREAS: Chemical/Biological Defense and Nuclear

OBJECTIVE: Augmenting the current abilities of deployed M21 Chemical Agent Automatic Alarms (M21) to perform cloud tracking and determine cloud distance using commercial-off-the-shelf (COTS) equipment. To do this, a new spectral manipulation approach must be developed to eliminate spectral background problems attributed to scanning.

DESCRIPTION: Currently fielded M21s are designed for passive stand-off chemical agent detection with a limited scanning range (seven positions), and no cloud tracking or range finding capabilities. Currently fielded M21s can not distinguish between a 600 x 100 m cloud at 5 km or a 300 x 50 m cloud at 2.5 km. These limitations can be corrected by merging data from multiple M21s mounted on COTS scanning stands (one M21 per stand). For example, two scanning M21s placed approximately 500 m apart (on mobile, stationary and shipboard platforms) can track, determine cloud diameter, and determine accurate distances and estimate concentrations for clouds up to 5 km away. The M21 is ideal for COTS integration, because collection of wavelength-resolved intensity data can be externally controlled using personal computer (PC) with no modification to fielded M21s for chemical agent detection. A single PC could control four scanning M21 assemblies, merge cloud mapping data from each assembly, rapidly determine agent identity, and provide the user with relevant real-time cloud threat information. The critical developmental component will be completely eliminating spectral background problems by applying a new spectral manipulation approach that will utilize the M21 interferometer as a wavelength-resolved radiometer.

PHASE I: Develop a new spectral manipulation approach needed to solve background problems associated with scanning. Build, evaluate, and refine the interface between M21s and commercial scanning stands. Evaluate data merging to produce multi-dimensional mapping.

PHASE II: Develop or integrate proper tracking and identification algorithms of which most will need to be developed. Build a deployable system and develop procedures to facilitate the rapid upgrade of currently deployed M21s.

PHASE III DUAL USE APPLICATIONS: Support anti-terrorist efforts at national and international events (Olympic games, super bowl, etc.). Track releases and supply real-time data from environmental disasters such as toxic releases from chemical plant explosions.

#### REFERENCES:

Grim, L., Gruber, T. C., Ditillo, J. Evaluation of Passive FTIR Algorithms, Proceedings of the Third Workshop on Stand-Off Detection for Chemical and Biological Defense, p. 251, 1994.

KEYWORDS: Chemical warfare, tracking, detection, infrared, M21